

CHAPTER XI

FRANCE, BELGIUM, HOLLAND, AND GERMANY 1944-5 (OPERATION "OVERLORD")

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SECTION I. SURVEY ORGANIZATION AND NARRATIVE
(see Sketch Maps Nos. 11 and 12)

General picture of the Survey organization

The build-up of the British survey organization for service with the Allied Expeditionary Force in Western Europe has been described in Chapter III.

When operation "Overlord" was launched in June, 1944, the allied survey organization was as under:—

(a) SUPREME HEADQUARTERS (S.H.A.E.F.)

Survey Directorate. (Map and Survey section. G-3 Division.)

Director of Survey—Brigadier A. B. Clough (British).

Deputy Director—Colonel H. J. McCrimmon (U.S.).

Chief Clerk (U.S.).

Composed of integrated British and American personnel numbering 10 officers and 21 British other ranks and U.S. enlisted men it was originally formed in December, 1943, for duty with the "Overlord" planning staff under the Chief of Staff to the Supreme Allied Commander (C.O.S.S.A.C.). It was organized as follows:—

Survey sub-section. (Geodetic policy and research. Triangulation and field survey control. Radar survey control. Air survey photography and air survey mapping.)

Lieut.-Colonel (British).

Major (U.S.).

Map sub-section. (Mapping and map supply policy. Co-ordination of revision programmes. Special map production.)

Lieut.-Colonel (U.S.).

Lieut.-Colonel (British).

Captain (U.S.).

Administration and Stores sub-section. (Administration of the section. Accommodation. S.H.A.E.F. Map Library and Map Store. Map distribution policy. Kodak negative library. Stores, etc.)

Major (British).

Captain (U.S.).

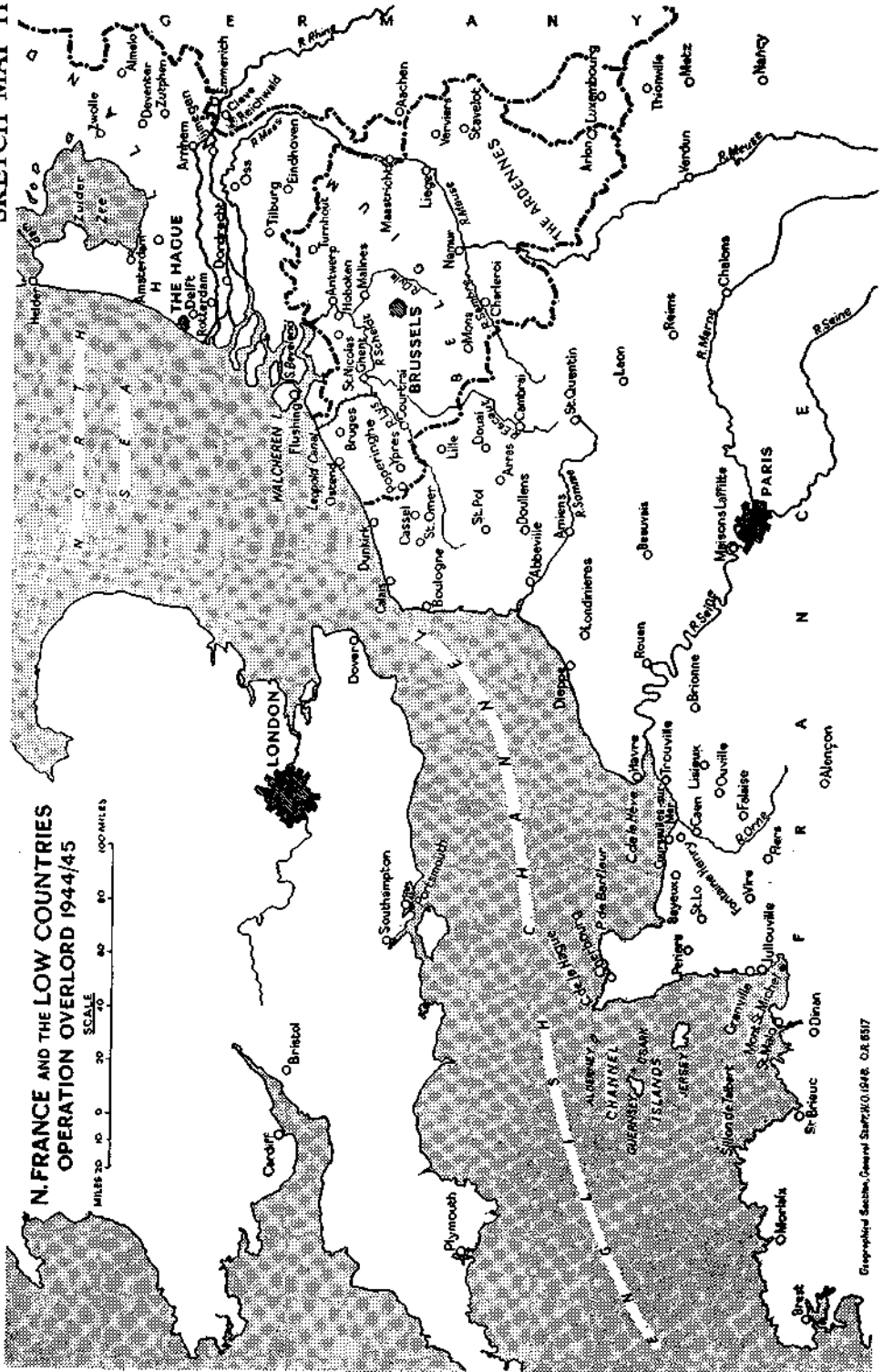
Clerks, draughtsmen, computers, map storekeepers.

(21 British other ranks and U.S. Enlisted Men.)

Most of the British personnel had been working together for some months on survey planning; firstly at G.H.Q. Home Forces, and subsequently at H.Q. 21 Army Group. Colonel McCrimmon had been employed on the staff of the Chief of the Intelligence Division under the Chief Engineer, E.T.O.U.S.A., in London, and had thus been in close touch with the British survey planners. From its formation under C.O.S.S.A.C. in December, 1943, the Survey Directorate continued its planning and mapping control activities at high pressure during the six months leading up to "D"-day on 6th June.

Under the direct control of the Survey Directorate a map store was opened at S.H.A.E.F., whose main purpose was to supply the needs of all S.H.A.E.F. divisions and branches. A map library was also organized, in which it was aimed to hold a specimen copy of every map that was likely to be needed for reference purposes. The Survey sub-

SKETCH MAP II



Geographical Section, General Staff, G.O. 15448. O.R. 8517

section built up a trig library holding triangulation and other survey data and records of all areas in the theatre which were likely to be of operational interest.

To provide facilities for local map drawing and reproduction at S.H.A.E.F. level, authority was obtained for No. 13 Map Reproduction Section R.E. and No. 9 General Field Survey Section R.E. to operate under the technical control of D. Survey (S.H.A.E.F.). Later on these units were transferred from 21 Army Group to S.H.A.E.F. for all purposes. They were very fully employed on the preparation of high-security maps of all sorts for the use of S.H.A.E.F. staffs in connection with planning and operations, and on the preparation and production of much basic work of a special nature for use by field formations.

(b) 21 ARMY GROUP

Headquarters. The Survey Directorate was organized as under:—

Director of Survey (Brigadier A. Prain).

Deputy Director (D.D. Survey) (Colonel H. A. L. Shewell).

(Primarily responsible for map supply and distribution.)

Asst. Director (A.D. Survey).

(Triangulation, field surveys including radar surveys, air survey, survey intelligence, and captured maps.)

Deputy Asst. Director (D.A.D. Survey).

(Mapping and map production.)

Assistant (Captain).

Army Group Units.

515 Field Survey Company R.E.

4 and 5 Field Survey Depots R.E.

4, 5 and 9 General Field Survey Sections R.E.

(No. 9 under S.H.A.E.F. technical control.)

13, 14, 15 and 16 Map Reproduction Section R.E.

(No. 13 under S.H.A.E.F. technical control.)

1 Air Survey Liaison Section R.E.

(c) BRITISH SECOND ARMY

Headquarters. The Survey Directorate was organized as under:—

D.D. Survey (Colonel A. W. Heap).

A.D. Survey. (Triangulation and field surveys.)

D.A.D. Survey. (Mapping, map supply and distribution.)

Survey Liaison Officers (Captains). (One to each corps under command. For survey contacts with corps and divisions on map supply and distribution matters.)

Army Troops Units.

14, 519 and 521 Field Survey Companies R.E.

3 (Army) Field Survey Depot R.E.

1, 2 and 3 General Field Survey Sections R.E.

(d) FIRST CANADIAN ARMY

Headquarters. The Survey Directorate was organized as under:—

D.D. Survey (Colonel H. Meuser, R.C.E.).

A.D. Survey. (Triangulation and field surveys.)

D.A.D. Survey. (Mapping and air surveys.)

Captain. (Map supply and distribution.)

Survey Liaison Officers (Captains). (One to each corps for contacts with corps and divisions on map supply and distribution matters.)

Army Troops Units.

2 Canadian Field Survey Company R.C.E. (Field surveys.)

3 Canadian Field Survey Company R.C.E. (Reproduction.)

4 Canadian Field Survey Company R.C.E. (Mapping and air survey.)

1 Canadian (Army) Field Survey Depot R.C.E.

(*Note.*—It will be observed that the Canadian Field Survey Company organization was on a different basis from the British. In the latter, the units were self-contained, each having its quota or personnel and equipment for field surveys (topographical), drawing (including air surveys), and map reproduction. In the Canadian Army, the units were organized on a functional basis, one being wholly for field-survey work, one for mapping and air surveys and the third for map reproduction and printing.)

(e) HEADQUARTERS ALLIED EXPEDITIONARY AIR FORCE (A.E.A.F.)

Under British policy, the Military Survey Service was responsible, as a common user service, for supplying the mapping needs of both the Army and the Royal Air Force. During the early war years, therefore, it was arranged that a survey officer should be held on the establishment of the principal Air Commands in Great Britain, with a small staff to operate map stores and to carry out special map drawing and other miscellaneous jobs. When, therefore, an integrated A.E.A.F. Headquarters was assembled, a Map Section was allotted to it, organized as under:—

D.A.D. Survey (Chief of Section—Major E. G. Godfrey) (British).

Deputy Chief of Section—Major (U.S.).

Clerical office 3 clerks (Corporals W.A.A.F.).

Drawing office 1 Serjeant, 1 Corporal, 2 Draughtsmen.

Map Store 1 Corporal, 3 other ranks.

The section was at first placed under the navigation officer, but this was not satisfactory. As in all cases of map and survey activities, the principal contact should be with the "Operations" and "Planning" branches of the staff. It was therefore agreed that it should be transferred so as to come directly under the Deputy Chief of Operations and Plans, and this proved to be a very satisfactory arrangement.

The problem of map supply is dealt with in Section 7 of this chapter and will not be elaborated here. For clarity, however, it should be understood that the Military Survey Directorate at the War Office was responsible for the production and supply of adequate stocks of whatever types of maps were considered necessary for the R.A.F. In cases where the R.A.F. was operating under or in conjunction with an army formation, for example the 2nd Tactical Air Force (T.A.F.) with 21 Army Group, it was the responsibility of the survey directorate with the military formation concerned to supply its map requirements.

In the case of the A.E.A.F. there were, however, many formations and other map users who did not come in the same supply category as 2nd T.A.F., and it was necessary that their mapping needs should be properly safeguarded. It was also essential that there should be a responsible agency for co-ordinating the supply of maps to all the air commands, sub-formations and units of the A.E.A.F., whether or not the actual physical supply would be arranged for by an army formation. Being in close touch with the "Plans" and "Operations" branches, the Map Section was in a position to obtain early and first-hand information about future air operational policy and, in so far as this affected design, supply, or distribution, was able to take whatever action was necessary to ensure that the requirements were met. With the development of radar aids to navigation, the section chief was responsible for much of the work concerning the initiation of field surveys for fixing the positions of the radar stations, and the preparation of the special lattice maps which were used in connection therewith.

The Map Section was, in effect, a direct descendant of a similar section which had been operating under Major Godfrey at H.Q. Air Defence of Great Britain (A.D.G.B.) during the years 1940-44. This officer with part of his staff was transferred from A.D.G.B. to A.E.A.F. and, until the latter went overseas, the two sections worked more or less as one. On the departure of H.Q. A.E.A.F., the map supply duties for A.D.G.B. were left in the capable hands of the W.A.A.F. officer who had for some time been assistant to the section chief.

During the planning stage the section was kept extremely busy. Map supply for training, and for the air operations that were constantly being carried out all over the coastal areas of Western Europe, was a major item, and large map stores were controlled by the section for this purpose. Operation boards for the various air operations control rooms were constructed. Special maps for a large variety of purposes were drawn and reproduced to meet the needs of the air staffs. Special map tables were also constructed for use in the headquarters ships of the Royal Navy which operated off the Normandy coast for controlling air operations during and after the assault on "D"-day.

On 21st September, 1944, part of the Map Section moved overseas with main H.Q. A.E.A.F., which was located alongside S.H.A.E.F. at Versailles. The Section Chief was at all times under the technical control of D. Survey S.H.A.E.F., who was responsible for all survey and mapping matters for both ground and air forces. In October there was an organizational change. H.Q. A.E.A.F. was disbanded as a separate headquarters and was absorbed into S.H.A.E.F. as S.H.A.E.F. (Air). The Map Section then became S.H.A.E.F.(Air)/Maps. The rapid advance of the allied forces during September from the Normandy bridgehead across the Seine and through north-eastern France and Belgium was a source of anxiety and hard work to the section as it was to all others who were concerned with map supply. The lull in October came as a welcome respite.

On the map reproduction side, much assistance was given to S.H.A.E.F.(Air)/Maps by 942 Topographical Aviation Battalion, an American engineer topographical unit serving with IX U.S. (Tactical) Air Force. This unit undertook the reproduction of many special

maps for use by the allied air forces and staffs from material supplied by S.H.A.E.F.(Air)/Maps.

The provision of maps for the allied airborne forces was a subject of much interest and activity on the part of the Map Section, especially in the early stages, before the formation of H.Q. First Allied Airborne Army with its own survey representation.

During February, 1945, when S.H.A.E.F. opened an advanced headquarters in Rheims, S.H.A.E.F.(Air)/Maps moved forward from Versailles, and as the S.H.A.E.F. Survey Directorate temporarily remained back at Versailles with S.H.A.E.F.(Main), an advanced S.H.A.E.F. map store was opened up at Rheims which was looked after by S.H.A.E.F.(Air)/Maps. By this means the needs of the staff divisions at both main and advanced headquarters were adequately met.

After the autumn lull, the *tempo* of operations quickened up again with the enemy offensive in the Ardennes, the approach to and crossing of the Rhine, and the rapid advance into Germany. A final move of the Map Section took place when S.H.A.E.F. moved forward to Frankfurt, and this was its final destination until disbanded in June, 1945.

U.S. ARMY TOPOGRAPHICAL ORGANIZATION

This subject will only be dealt with briefly, in so far as it affected the general survey set-up for operations in western Europe. Under basic U.S. Army policy, all map and survey matters were handled by the engineer staffs at formation headquarters. This fundamentally differed from British practice, where there was a separate survey service functioning with direct responsibility to the General Staff. Experience in the Mediterranean Theatre had indicated that this American organization had some weaknesses and, during the planning period for "Overlord," when co-operation for mapping and survey matters between British and U.S. representatives was of the most cordial and helpful nature, it was suggested, and strongly supported by the senior U.S. survey liaison officer, that some sort of compromise between the British and U.S. survey organizations should be adopted. This was to take the form of a specially selected topographical branch, to be allocated to the engineer sections at army group and army headquarters, which would concern itself solely with mapping and survey matters. This would then leave the Engineer staff as a whole to carry on with its normal engineer duties, and make sure that survey matters would not be side-tracked and neglected. This was agreed to by the War Department, and topographical branches, composed of officers and enlisted men with suitable survey qualifications, were appointed to the First (later Twelfth) U.S. Army Group, and to the First and Third U.S. Armies. They carried out their duties with conspicuous success.

The American unit organization was also different from the British. With each corps there was one engineer topographical company operating directly under the corps engineer, which was capable of carrying out field survey work on the corps front in conjunction with the corps observation battalion which corresponded to the British survey regiment R.A. It frequently happened that the survey platoons of the engineer topographical units were placed under command of the observation battalion for work within corps areas. These American units, like the British field survey companies, had a mapping or drawing platoon, and also reproduction platoons with mobile, lorry-borne

printing machines to enable them to undertake map production and printing in the field.

Each army had one engineer topographical battalion, which was organized as under:—

Battalion H.Q. and headquarter company.

Company A for field survey.

Company B for mapping, including air survey, map production, and printing. They were equipped with mobile lorry-borne reproduction plant.

There were no survey units directly at the disposal of U.S. Army Group Headquarters, as there were in the British Army, but the topographical branch at those headquarters exercised a general control over the mapping and production resources of the topographical units with armies under command.

Base map production and supply in the field was effected by having one or more engineer topographical battalions and map depot teams at the disposal of the Chief Engineer of the Communications Zone (Com. Z.). For mapping and survey matters, the Chief Engineer delegated technical control to the head of his Engineer Intelligence Division (Colonel H. Milwit) who was, in effect, the representative of the War Department in the European Theatre of operations for all mapping and survey activities, and acted as chief liaison officer with the British survey service. It is not too much to say that, by virtue of his high technical skill, administrative ability and ready co-operation, the working and social relations between the British and U.S. mapping and survey organizations were at all times close, effective and cordial.

Moves of units overseas

SECOND ARMY

The first survey troops to proceed to Normandy were the directorate and survey units of the British Second Army, who went over by detachments on light scales soon after "D"-day. All their vehicles had been waterproofed so as to enable them to get ashore from "landing craft" across the beaches. The residues of the units, consisting of those personnel not essential for the earliest tasks, and the bulk of the heavy vehicles crossed over later in June. The survey directorate accompanied Army H.Q. on "D" + 3.

The light scales organization for 519 and 521 Field Survey Companies, and the detachments in which they landed, were as follows:—

1st Detachment ("D" + 3). Reconnaissance detachment of 1 officer (O.C.) and 1 other rank with one 15-cwt. truck.

2nd Detachment ("D" + 4). Company H.Q. and drawing section consisting of 1 officer and 22 other ranks, with one 3-ton lorry, one water truck, one motor-cycle, and one cycle.

Topographical H.Q. 7 other ranks with one 3-ton lorry.

Two topographical sections each of 1 officer and 14 other ranks, with three 15-cwt. trucks and three motor-cycles.

3rd Detachment. Reproduction section. 1 officer and 22 other ranks, with two 3-ton lorries, one printing lorry, one photo-mechanical lorry, one trailer generator and one motor-cycle.

Photo section. 11 other ranks, with one 3-ton lorry, one camera lorry, one process lorry and two trailer generators.

The "residue" of each company consisted of 1 officer and 53 other ranks, with the following vehicles:—

Company H.Q. vehicles—Two 3-ton lorries, two 8-cwt. trucks, one trailer generator and one motor-cycle.

Topographical vehicles—Three 15-cwt. trucks and two 8-cwt. trucks.

Reproduction vehicles—Two 3-ton lorries, one printing lorry, one photo-mechanical lorry, one trailer generator and one motor-cycle.

14 Field Survey Company with 3 General Field Survey Section under command crossed over on light scales on "D" + 14.

1 and 2 General Field Survey Sections crossed over on light scales on "D" + 3 and "D" + 4 respectively each in one detachment only consisting of one officer and 21 other ranks, with one 3-ton lorry, two 15-cwt. trucks and three motor-cycles. The residue for each was four other ranks, one 3-tonner and one 15-cwt. truck.

3 (Army) Field Survey Depot went over on light scales in eight detachments (excluding the corps and divisional sub-sections which accompanied the headquarters of their respective formations). Two small detachments of the depot landed on "D"-day, second tide, under command of 1 and 30 Corps respectively, the main depot following in small detachments between "D" + 3 and "D" + 7. The rear depot crossed over about "D" + 14.

Some of the Army Group headquarters survey units reached Normandy during June, and were temporarily under command of Second Army. The units concerned were:—

4 Field Survey Depot R.E. (Maps). Completely overseas during June.

4 General Field Survey Section R.E. Over on light scales.

515 Field Survey Company R.E. Reconnaissance party only over during June.

5 Field Survey Depot R.E. (Stores). Two other ranks only over in June.

During July there was no change in the organization of Second Army survey units, which continued to be occupied on field survey work within the bridge-head, the printing of large scale (1/25,000) maps for all arms, the supply and distribution of maps on all scales from their own map depot, the revision of existing maps, and other miscellaneous tasks. The general field survey sections were placed, one each under command of the three field survey companies, two of which were employed on survey work in forward areas, with one in reserve. During the month the 21 Army Group units which had been temporarily under Second Army command, passed to L. of C. command, though still remaining under the technical control of Second Army.

21 ARMY GROUP

By the end of July the following Army Group H.Q. units were over in France, less their residues which were *en route*:—

4 and 5 Field Survey Depots R.E.

4 and 5 General Field Survey Sections R.E.

515 Field Survey Company R.E.

14 and 15 Map Reproduction Sections R.E.

A third field survey depot (No. 25) was allocated to 21 Army Group during July for employment as an L. of C. depot handling both maps and stores, which would be passed forward from Nos. 4 and 5 (Base) Depots.

In late April or early May, 1944, soon after Army Group H.Q. (Main) had moved to the south coast of England, the survey directorate had been split into two echelons, D. Survey and A.D. Survey going forward with main H.Q., while D.D. Survey, D.A.D. Survey and most of the directorate personnel remained at rear H.Q.

Survey (main H.Q.) crossed over to France on 4th August, D. Survey himself having preceded them by a few days, and rear Survey H.Q. followed on 12th-13th August. The directorate was then reunited at main H.Q. where it remained till the end of hostilities. A.T.S. clerks crossed over with rear H.Q., other A.T.S. personnel (draughtswomen and storewomen) having been replaced by men before "D"-day.

The three months during which the directorate was divided demonstrated clearly the disadvantages of splitting it in two echelons. Survey (main) was understaffed and overworked, and Survey (rear) was out of touch with the day-to-day needs and requirements of Second Army and 21 Army Group troops.

FIRST CANADIAN ARMY

The Canadian Army survey directorate was in Normandy by 25th July and, during the latter part of the month and early August, the following Canadian survey units took their place within the bridgehead:—

- 2 Canadian Field Survey Company R.C.E. (topographical).
- 3 Canadian Field Survey Company R.C.E. (reproduction).
- 4 Canadian Field Survey Company R.C.E. (mapping).
- 1 Canadian (Army) Field Survey Depot R.C.E.

U.S. ARMIES

For the assault operation the First U.S. Army was placed under command of 21 Army Group. The headquarters of the U.S. First Army Group did not exercise command overseas until the latter stages of the bridgehead operations, when the U.S. Third Army began to exploit the break-out. It became operational on 1st August, being renamed the Twelfth Army Group, and commanded both the First and Third U.S. Armies.

S.H.A.E.F. Survey Directorate

It might be well, at this stage, to consider the role of S.H.A.E.F. Survey Directorate in relation to the survey activities of the allied forces in the West European Theatre. Being a completely integrated Supreme Allied Headquarters, S.H.A.E.F. exercised command and control over all the allied forces at its disposal, of whatever nationality. With regard to survey this implied a centralized direction of allied survey and mapping policy. It was obvious that differences between allied technical methods and survey training made it impracticable to aim at complete standardization either for field survey work, map production and printing, or for map supply and distribution. There were no grounds, anyway, for suggesting that one method was right and the other wrong. The possibility, however, that formations of one nationality might find themselves temporarily under command of another allied formation, and the certainty of their having to co-ordinate their surveys

at points of junction, made it essential to bring about a certain degree of standardization concerning co-operation between engineer and artillery surveys and the recording and maintenance of survey data. It was also an agreed policy that all allied ground and air forces under S.H.A.E.F. command should use the same basic standard maps, grids, and map co-ordinate system. The Royal Navy and U.S. Naval Forces were also much concerned with the map co-ordinate and grid systems in connection with gunnery control during the assault, and the radio control of aircraft from headquarter ships. This made it desirable to draw up and publish Operational Policy Memoranda laying down certain basic rules regarding the above. D. Survey (S.H.A.E.F.) drafted two such memoranda for publication by the Chief of Staff. They were:—

- | | |
|-----------------------------------|------------------|
| 28 Artillery and Engineer Survey. | } See Appendices |
| 9 Map Co-ordinates. | |

S.H.A.E.F. also published a summary of existing War Office and War Department policies concerning map supply, together with a statement showing their application to "Overlord."

S.H.A.E.F. Survey Directorate had, during the planning period, made investigations into the triangulation systems of western Europe, and had prepared a series of trig lists covering all likely operational areas. These were issued to all concerned, together with fully descriptive notes about the various national trig systems and their characteristics. Throughout the whole campaign S.H.A.E.F. continued to issue technical information of all sorts to the allied survey organization in the form of Survey Technical Instructions.

At a conference between survey representatives of the War Office and the War Department in Washington soon after the entry of the United States into the war (*see* Chapter IV), it had been agreed that the War Office should be responsible for mapping policy and the initial production of basic map series for the whole of the European Theatre. As the responsible officer for all survey and mapping matters overseas within the area of S.H.A.E.F. control the Director of Survey (S.H.A.E.F.) maintained a very close liaison with the Director of Military Survey at the War Office on all matters concerning the production of these map series. As a result of his personal contacts with planning staffs at G.H.Q. Home Forces, at 21 Army Group, C.O.S.S.A.C. and at S.H.A.E.F. successively, he was able to ensure that the mapping programmes were being co-ordinated and kept up to schedule to conform with military plans.

It had been agreed also that, during the period of concentration and training in the United Kingdom, the assault itself, and the early period of subsequent operations, the British survey service would be responsible for providing stocks of all basic standard maps to the American forces. Thereafter, as soon as direct channels of communication had been opened up between the United States and France, the War Department would take over responsibility for bulk supply to U.S. forces within the Theatre. All this necessitated very close liaison between the D. Survey (War Office), D. Survey (S.H.A.E.F.), and Colonel Milwit (E.T.O.U.S.A.).

In view of the geographical proximity of the United Kingdom to the operational area, the prospective size of the allied forces, and the fact that most of the bulk stocks, anyway for the British, would be printed under War Office arrangements in the United Kingdom, it was decided that bulk map supply would normally be effected direct between the War Office and the consumer. This meant that D. Survey 21 Army Group dealt direct with the War Office

for the physical supply of map stocks, and this applied equally to E.T.O.U.S.A. (later Com. Z.), for bulk stocks which the Americans would be drawing from War Office sources. The same principle of direct dealing, cutting out S.H.A.E.F. except when policy questions arose, applied to the supply of technical survey stores for use by British units. This system avoided much duplication of effort and office work and saved a lot of time.

Although the production of most of the basic small and medium scale maps was a War Office responsibility, there were many items of map production which came directly under the control of D. Survey S.H.A.E.F. in both the planning and operational stages. Notable amongst these was the 1/25,000 mapping from air photographs of large areas of northern France which were not already covered with maps on that scale. The co-ordination and control of revision programmes for large scale maps of the whole Theatre was also a S.H.A.E.F. responsibility. Before "D"-day, two of the more important items controlled by S.H.A.E.F. were the surveys of enemy beaches from air-photos for the determination of beach gradients (*see* Chapter XIV, Section 10), and the air surveys of potential airfield sites in Normandy (*see* Section 5).

For S.H.A.E.F. Survey Directorate it was always a case of looking well ahead, keeping well briefed about probable future plans, forecasting future mapping, revision and survey requirements, and taking all necessary steps, in conjunction with the War Office, the chief topographical officer (E.T.O.U.S.A.) (and through him the War Department), and the allied Army Groups, to ensure that all possible requirements could and would be met.

It was always considered likely that, under emergency conditions, an interchange of map stocks between allied formations might be necessary and that, under such conditions, D. Survey (S.H.A.E.F.) would be responsible for issuing the necessary orders for such transfers. It so happened that this contingency frequently arose, but the close and friendly relations that existed between British and U.S. survey staffs in the field usually enabled local transfers of map stocks to be effected without any need for S.H.A.E.F. interference.

Another item which from December, 1944, was centrally controlled by S.H.A.E.F. was the survey of radar stations in connection with the establishment of "Gee" Chains for navigational control. Up to that date 21 Army Group had controlled and executed all radar surveys irrespective of their location. S.H.A.E.F. now dealt direct with the R.A.F. Group concerned to ascertain requirements, and delegated the actual survey work to the appropriate Army Group, dependent on the location of the station.

In order to keep all concerned informed of the ever-changing situation regarding the state of publication of standard map series, revision programmes, and kindred matters of general survey interest, progress reports were issued at frequent intervals by S.H.A.E.F. Survey Directorate, indicating the week-to-week mapping and revision situation and future prospects.

By these means S.H.A.E.F. was able to effect a proper co-ordination and control of the allied survey effort. In many respects it will be noted that the S.H.A.E.F. Survey Directorate was organized and functioned on somewhat different lines from the corresponding directorates at G.H.Q. Middle East, and at A.F.H.Q. in the Mediterranean Theatre. As these latter were separated by long distances from the United Kingdom, and as sea communications, especially in the mid-war years, were long and uncertain, they were necessarily more independent and self-contained with regard to bulk map production and supply.

Survey staff for H.Q. Allied Airborne Army

During August survey officers were assigned for duty with the newly formed headquarters of the First Allied Airborne Army (F.A.A.A.). By the nature of things, their map demands were extensive, varied, and always urgent. It was obvious that expert technical control of map supply at Army H.Q. was vital but, when it was suggested that survey officers should be appointed for this purpose, it was stated that no more officers could be added to the establishment of Army H.Q. as it was already large enough. There was, however, no question about their needing survey assistance. Two extra British officers were therefore posted to the S.H.A.E.F. Survey Directorate, from where they were detached for duty with H.Q. F.A.A.A. In one respect there was a great advantage in this procedure; security for airborne operations was essential, and the fact that these officers wore the S.H.A.E.F. flash on their shoulders, instead of the betraying Airborne Army flash, introduced a disguise of some merit when they were visiting map supply organizations or depots in their quest for map stocks. Similar arrangements had to be made for the American officers who completed the integrated survey team at Army Headquarters.

Further build-up of survey units

August witnessed the break-out from the Normandy bridgehead, the overrunning of the Brittany peninsula, and the spectacular pursuit of the German forces through northern France and Belgium. During the first half of August the main and rear portions of 21 Army Group Survey Directorate had crossed over and were reunited at Main H.Q. No. 25 Field Survey Depot had arrived overseas, and Nos. 14 and 15 Map Reproduction Sections were fully working within the bridgehead by late August. No. 25 Field Survey Depot joined 21 Army Group as an advanced L. of C. depot for maps and stores, and an advanced party of No. 16 Map Reproduction Section had also crossed over. No. 13 Map Reproduction Section and No. 9 General Field Survey Section who had for some months been under S.H.A.E.F. control, were finally transferred to S.H.A.E.F. for all purposes during August. The only 21 Army Group H.Q. survey unit still in the United Kingdom was No. 1 Air Survey Liaison Section R.E.

As a result of a somewhat unexpected and abnormal demand for 1/25,000 maps by all arms, especially in the close "bocage" district of Normandy, further mobile printing resources were demanded by Second Army, and agreed to by War Office. This entailed the addition to each field survey company of two printing lorries and one extra graining machine, together with the necessary technical and supervisory personnel. These were obtained mainly from Nos. 520 and 523 Field Survey Companies which were still in the United Kingdom.

The speed of the pursuit threw a great strain on the map supply and distribution organization. This will be referred to in more detail in Section 6, but it proved that an ordinary standard field survey depot, as then constituted, was inadequate to deal with the situation at Army Group level. Local civilians and extra military labour amounting to about 100 assorted personnel were employed during most of August. These included French typists, Spanish pioneers, French civilians, British pioneers and, on occasions, a general field survey section, two topographical sections from a field survey company and all the available survey reinforcements in the country. Their work was

mainly concerned with the handling and sorting of bulk stocks arriving from the United Kingdom, and sending them forward to the rapidly advancing armies. It was also clear that the depot's unit transport was inadequate even for its purely domestic affairs, and it was necessary to attach permanently one 15-cwt. truck for rations and water, one jeep to enable the O.C. to go to and fro between the depot and the docks, and one motor-cycle for the collection and delivery of mail and messages. The depot was also given first call on the 10-ton lorries belonging to the map reproduction sections for forward delivery of maps in bulk.

With Second Army, where the augmented No. 3 (Army type) Field Survey Depot was operating, all went well till the last week in August when it was found necessary to allot to the depot the personnel and transport of two topographical sections from a field survey company, and two general survey sections, to speed up the moves of the depot. Twenty 3-ton R.A.S.C. lorries and a platoon of pioneers had also to be borrowed. The Canadians experienced similar troubles during the advance owing to shortage of personnel and transport with their depot.

Departure of U.S. Base topographical organization overseas

The U.S. Base and L. of C. organization, known as the Communications Zone (Com. Z.), started moving over to France during August. It formed a separate American Command quite distinct from the U.S. Army Groups and its Commanding General was responsible directly to General Eisenhower, the Supreme Commander. The staff of S.H.A.E.F., though working in close co-operation, did not however exercise any command function over Com. Z. The base survey organization for U.S. forces in the Theatre, to deal with bulk map production, printing, and supply, was included within the Com. Z. command, under the control of the Chief Engineer, who, as stated previously, delegated the work to the Chief of his Intelligence Division, Colonel H. Milwit. This officer had been working in close touch with D. Survey (S.H.A.E.F.) and the War Office since 1942, and the happy, close co-operation between them continued through to the conclusion of hostilities. During the planning period he regularly attended the fortnightly map production conferences at the War Office, and was, with his staff, in almost daily personal touch with D. Survey (S.H.A.E.F.) to the mutual advantage of all concerned.

Field surveys

The triangulation work and check surveys which were carried out by both British and U.S. units during the bridgehead operations, mainly in connection with the provision of a control framework for the artillery, are dealt with in Section 3. When the break-out occurred and the pursuit was on, the need for this work temporarily lapsed. All survey units were, however, provided with trig data for the whole area and could, if the need arose, start work anywhere and provide the artillery with their necessary control points at short notice.

Map supply anxieties

The rapid pursuit following the break-out from Normandy was a source of considerable anxiety to the U.S. topographical branches at the headquarters of U.S. formations, especially in connection with General Patton's Third Army,

which raced along the Loire valley, across the Seine, and on towards Verdun and Metz at a great pace. There had been some difficulties regarding the transport of bulk stocks across the Channel and over the beaches, and during the first few critical weeks supplies were short. Ships containing map stocks printed in the United States, had crossed the Atlantic and were lying around the British coast. Cherbourg had been captured but was in a state of devastation and was not yet able to handle much shipping. Urgent representations at a high level resulted in the cargoes of the map ships being discharged. Road transport, which was at a premium, was obtained for rushing the maps forward, further stocks were flown over from the United Kingdom by air and, in one way or another, the advancing troops were just kept supplied, though not without causing much anxiety to the survey staffs concerned.

French Service Géographique (Institut Géographique National)

In late August Paris was occupied and, as this was in the U.S. Zone of operations, D. Survey (S.H.A.E.F.) allocated to the Chief Topographical Officer (Com. Z) the responsibility of investigating and controlling the map production resources of the French Service Géographique, which had its headquarters in Paris. First contact with this was made by the topographical branch of 12th U.S. Army Group, and it was satisfactory to find that General Hurault, who had worked so closely with the War Office immediately before the war, and with the Director of Survey, British Expeditionary Force, during 1939-40, was still in command. He proved most co-operative and placed all his resources at allied disposal. Com. Z. immediately sent a liaison officer to install an office at the headquarters of the Service Géographique and, with General Hurault's assistance, lithographic printing firms were requisitioned, and urgent programmes of map production were begun to meet the existing critical map situation. An officer from S.H.A.E.F. Survey Directorate also visited General Hurault to establish contact and obtain urgently required French triangulation data and other information.

Departure of S.H.A.E.F. Survey Directorate overseas

Early in September a forward echelon of S.H.A.E.F. Survey Directorate joined S.H.A.E.F. (Main) at Jullouville in the Cherbourg peninsula. The remainder crossed over soon after when S.H.A.E.F. (Main) had moved to Versailles. There it remained during the whole winter of 1944-45. The S.H.A.E.F. map store and library were opened up at Versailles and good accommodation was found nearby for 13 Map Reproduction Section and 9 General Survey Section who spent a busy winter providing the planning and other staffs with their many and varied special map requirements.

Staff increases

One result of the intensive map supply activities during late August and September, 1944, was the need for an increase in the establishment of Survey Directorates at the H.Q.s of both 21 Army Group and Second Army. The existing staffs were working at great pressure and were unable, without the risk of breakdown, to cope with the enormous volume of work that required urgent treatment. An extra D.A.D. Survey (Major) was therefore added to both, to assist with map supply and distribution work. The rank of the officer

commanding No. 4 Field Survey Depot, which was handling great quantities of maps under very trying conditions, was upgraded to captain, and two additional subalterns and extra personnel were added to the unit.

Survey Directorate 21 Army Group moves to Brussels

During September, H.Q. 21 Army Group, having moved forward from the bridgehead to Amiens, moved on again to Brussels where it remained for the winter months. Although 14 Map Reproduction Section and Nos. 4 (Maps), and 5 (Stores) Field Survey Depots still remained back in the Bayeux-Caen area, all the other 21 Army Group H.Q. survey units, including No. 1 (Air) Survey Liaison Section which had crossed over from the United Kingdom rather later than the others, were now in the Brussels area.

Military Geographical Institute, Brussels

D. Survey 21 Army Group made early contact with the Director of the Belgian Military Geographical Institute in Brussels, from whom he received most valuable co-operation. Unlike the French Service Géographique, which had managed to continue its work on a more or less civilian basis during the German occupation, the Belgian Institute had practically ceased to function. Its records had been stolen, and most of its plant and equipment had been removed. Fortunately a number of civilian printing presses, which had been requisitioned by the German mapping service, were found in good condition, also large quantities of paper and printing stores. Personnel of 15 and 16 Map Reproduction Sections were flown up from Normandy to operate these machines, their own equipment following later by road. As Brussels was in the British Zone of operations its local map printing resources were controlled by D. Survey 21 Army Group.

Survey stores

No. 25 Field Survey Depot, which had arrived from the United Kingdom, was installed at Brussels for handling both maps and stores. Owing to the continuation of the rapid advance, it was found necessary for No. 5 (Stores) Depot, which was still back in Normandy, to continue for the present to supply paper and survey stores direct to the army depots. The rapidly increasing distance between consumer and supplier made it difficult for the armies to send back to No. 5 Depot for their requirements and, as much of the L. of C. transport pool had been allotted to the two armies to keep them moving, there was a shortage of transport in the back areas. It was, therefore, an anxious and difficult matter to get the map stocks and survey stores forward but it was accomplished as a result of intensive efforts on the part of those concerned.

Map supply and distribution

Map supply and distribution will be described in more detail in Section 6, but a few remarks concerning the organization involved will not be out of place here. The map supply situation with armies became very critical during September. Stocks undoubtedly ran short, and issues had to be cut, but the formation commanders never had cause to complain that operations had been prejudiced by a lack of maps, and it is probable that the situation appeared to be more serious to the survey staffs themselves, who knew the real picture, than

to the actual map users. The fact is that no one type of map supply organization will successfully meet every operational contingency. The basic system, which should be framed to meet the most probable normal requirements, must be sufficiently flexible and capable of adjustment to ensure that the maps which become available from the various sources of supply will be put into the users' hands in plenty of time to be of use. This means that the survey staffs must be ready, in emergency, to throw in personnel and transport from other survey units when normal pool transport is unobtainable. The use of daily air-lifts for map delivery on a long-term basis, to bridge a crisis caused by temporary shortage of stocks and rapidly lengthening communications, should also be considered as a flexible and sure means of meeting a rapidly changing map situation. This may sometimes, as occurred during the September operations, entail air-lifts direct from the main source of supply (*e.g.*, the War Office). The need for conducting officers cannot be over-emphasized. Without them map consignments will often be lost or mislaid.

Captured enemy map stocks

There was another item which demanded flexibility of treatment—the investigation and sorting of stocks of captured enemy maps. This formed a big and important task for both British and American survey services. The job was urgent, as the acquisition of new or recently revised enemy map material was needed for our own new map production and revision. The personnel of field survey units was at first used for this purpose, at the expense, of course, of other productive work, and in Paris, where enormous stocks of German maps were found, the French provided personnel to assist.

At a later date it was found necessary to organize special “Captured Map” sections for dealing with this work.

“Kodaline” sections

During operation “Overlord,” as in other major war theatres, the reproduction of maps in the field by large numbers of widely scattered survey units assumed vast proportions. A difficult problem arose concerning the distribution, recording, and revision of the reproduction material and the control and use of revised material so as to ensure that the kodalines held by units were up to date and consistent. Survey Directorates at all levels found it necessary to have “Kodaline” sections to look after this matter and, as it seems more than likely that similar conditions will apply in any other war, provision for this should be made in war establishments.

The effect of rapid movement on the survey organization

The ability of survey directorates and units to pack up and move quickly was of great importance. Second Army H.Q. moved six times during September, the longest move being 160 miles. This entailed six moves for 3 (Army) Field Survey Depot with its map stocks and stores, a considerable transportation problem. On two occasions the rear section with the survey stores was left behind to ease the strain. The field survey companies moved five times in that period. On one occasion, when very urgent printing programmes were in hand, they were deliberately left 50 miles behind Army H.Q. so as to avoid a disturbance of the programme. Normally, however, it is undesirable to have these units widely separated from Army H.Q. and the Survey Directorate.

Some aspects regarding the organization of survey units

There were many obvious merits in the British organization of field survey companies whereby they were self-contained, each with its own sections for field survey, drawing and map production. There were, however, many occasions in the western European Theatre when it was advantageous to concentrate individual resources together so as to facilitate a mass-production output of work. The Canadians organized their survey units on this principle of functional output. On balance it is considered that the British system was the better. It is probably easier to concentrate the drawing, printing or field sections together from the various units than to throw together a mixed team when occasion demands.

In mid-September there was a change in the Canadian survey organization. Hitherto they had worked with three separate companies, one for field survey, one for reproduction, and one for mapping. The programme of new mapping and revision from air photographs was daily increasing in importance. New personnel was being trained in the technique of air survey mapping, and an efficient and well-equipped organization, including multiplex plotting apparatus, was now available. It was decided, therefore, to form an Air Survey Company, consisting of H.Q., one air survey liaison section, eight air survey sections (for map compilation and fair-drawing), one proving section, and one photographic section. The inclusion of these two latter sections was considered desirable as, in the course of producing a map from air-photos, there were many occasions when photography and the preparation of printing plates for pulling impressions and proving the work were necessary. This new company was therefore self-contained, and was not dependent, for some of its essential processes, on other units which might be some distance away.

Sixth U.S. Army Group comes under S.H.A.E.F. command

An important organizational change within the Theatre during September was the arrival of the U.S. Sixth Army Group, which included the U.S. Seventh Army and the First French Army. These two armies, coming from the Mediterranean area, had effected a successful assault-landing on the southern French coast, advanced rapidly up the Rhone valley and contacted the right wing of the U.S. Twelfth Army Group, where they encountered strong resistance in the Vosges mountains and the Belfort gap. They had been originally mapped up by A.F.H.Q. in the Mediterranean but, at an agreed stage, they came under general survey control from S.H.A.E.F. and subject to map supply from Com. Z. A topographical branch of the Engineer Section had been provided for H.Q. Sixth Army Group and, in the case of the First French Army, although there was a shortage of survey equipment and trained survey personnel, they organized the equivalent of a small survey directorate at their Army H.Q. and co-operated well with the topographical staff at H.Q. Sixth Army Group, under whose technical control they were placed.

Mapping programmes for western Germany

The approach of the allied armies towards the German frontier made it necessary to hasten the programme of mapping work on all scales covering western Germany. The War Office had in hand the preparation of series on 1/250,000, 1/100,000, 1/50,000 and 1/25,000 scales. Part of the 1/50,000

programme, covering the probable U.S. operational zone in the south, was allocated to the U.S. base mapping organization in order to hasten completion. The 1/25,000 sheets were being produced by direct facsimile copying from German maps. Many of them were out of date, and S.H.A.E.F. took over responsibility for the control of a revision programme from air photographs. For some months the R.A.F. and U.S. Army Air Force had been photographing western Germany in accordance with the priority programme instituted by S.H.A.E.F. East of the Rhine the map series was divided up into blocks for revision by the Army Groups and Com. Z. The area lying to the west of the Rhine was retained for revision by the War Office. As events turned out, this was an unwise decision. In the case of large scale map revision, which will normally be the responsibility of the survey organization in the field, it is better that the areas which are likely to be most urgently required should be revised in the field by the formations which will be using the maps. If the War Office or some other distant organization is to take over a share of the work, it should be allotted an area further ahead, which can be worked on a longer-term basis. The Twelfth and Sixth U.S. Army Groups sub-allocated sheets of their areas to armies under command, the work being undertaken by the engineer topographical battalions. 21 Army Group sub-allocated part of their area to the British Second and First Canadian Armies, retaining a large block themselves. To deal with this latter, D. Survey formed an Air Survey Group by assembling together, in Brussels, several general field survey sections, including two from Second Army. This was a similar arrangement to that which had been adopted in the United Kingdom for the preparation of 1/25,000 maps of northern France before "D"-day.

In addition to the above revision programme, survey units were continually engaged in the preparation of special maps covering important areas, mostly from large scale air photographs.

Increase in the war establishment of No. 4 Field Survey Depot R.E.

Previous mention has been made of the growing task of investigating and classifying captured enemy map material and other survey records. This, combined with the ever-increasing labour in connection with the recording, storing and issuing of kodamine negatives of map series in the Theatre, made it necessary for D. Survey 21 Army Group to ask for an increase of establishment so as to form two new sections at his headquarters, one for enemy maps and records, and one for dealing with the kodamines. As no further additions were permissible to the war establishment of H.Q. 21 Army Group, the establishment of No. 4 Field Survey Depot was adjusted. The responsibilities and work of this unit, which was the principal map depot with 21 Army Group, had grown so much that a special establishment was approved. As a result it now consisted of three officers (captain and two subalterns), one warrant officer Class I, and 83 other ranks with the following transport:—

Motor cycles	2
Car, 2-seater	1
Trucks, 15-cwt.	3
Lorries, 3-ton	3
Lorries, 10-ton	5

A comparison between this and the original establishment of the unit will indicate the changed conditions. The depot was holding at that time between 15 and 20 million maps, a figure which rose still higher later on.

The German counter-offensive in the Ardennes

The comparative lull during October, November and early December enabled all concerned to go ahead with their mapping and revision programmes, to build up map stocks, and to carry out essential field surveys for artillery requirements along the front. Map planning for future operations was a major item, including preparations for the advance to, and the crossing of, the R. Rhine. The lull was broken during the latter half of December, when German forces counter-attacked strongly in the Ardennes, making a deep bulge in the allied line extending westwards nearly as far as the R. Meuse. The resulting quick moves of supporting formations, both British and American, caused many unexpected complications regarding map issues. It was a good test for the allied map supply organization, and afforded proof of the excellent liaison and co-operation that existed between British and American survey staffs and units. As a temporary measure, the survey activities of the First and Ninth U.S. Armies were transferred to the control of D. Survey 21 Army Group, though Com. Z. continued to be responsible for the supply of bulk map stocks to the advanced map depots serving both these armies.

As a precautionary measure, in case the enemy break-through should be extended across the Meuse into central Belgium, the topographical sections of two of the Second Army survey units were brigaded, and worked as one team under the command of O.C. 521 Field Survey Company. They carried out survey work for possible artillery requirements along the R. Dyle, just east of Brussels. Happily the contingency did not arise and the work was stopped after two weeks of activity.

A.T.S. Drawing Sections

The first of two A.T.S. Drawing Sections arrived for work under D. Survey 21 Army Group in November. They had been trained at the R.A.F. Photographic Station at Medmenham for the preparation of sortie diagrams and other work in connection with survey photographic programmes, and they were located with the R.A.F. squadron which was undertaking survey photography for 21 Army Group. They more than justified their inclusion as part of the survey team.

Preparations for the Allied offensive into Germany

By the end of January, 1945, vigorous action had practically eliminated the whole of the Ardennes bulge. Sixth U.S. Army Group in the south was in process of squeezing the German forces out of the Colmar pocket. In the north the British Second Army had successfully cleared the enemy out of the area between the Rivers Maas and Roer. Only in the Saar was the enemy aggressive. Everywhere else the Allies had regained the initiative. In the east, the Russians had opened a big offensive on a broad front from East Prussia to the Carpathians.

Normal field surveys were carried on along the front for checking triangulation and establishing new control. A special survey project was undertaken by the Canadians in the Antwerp area, in connection with the installation of detection equipment against V-weapons. The survey sub-section of S.H.A.E.F.

Survey Directorate concentrated its efforts on the preparation of trig lists of western Germany. In view of the large amount of computing work which field formations were undertaking in connection with the conversion of trig values from one system to another, consideration was given to the advisability of forming a centralized computing centre at S.H.A.E.F. After discussions with Army Groups, it was decided not to proceed with the project, which would have entailed the detachment to S.H.A.E.F. of many of their best computers.

During February, the Belgian Cartographic Institute, under the general guidance of D. Survey 21 Army Group, formed a special topographical section for air survey consisting of Belgian personnel. This section was attached for training to the Canadians and made excellent progress.

With past experience as a guide, and the probability of quick movement over long distances, preliminary steps were taken in 21 Army Group towards the formation of a mobile advanced map depot which could move forward at short notice without disturbing the elaborate set-up of the two existing Army Group map depots. Personnel from these latter were used for formation of this map depot on wheels.

A new U.S. Army (Fifteenth) became operational during March, involving the usual allocation by Com. Z. of an advanced map depot just to the rear of the army area. The stage was now set for the assault crossing of the Rhine. Survey staffs and units were working under high pressure, and a large and varied assortment of maps, defence overprints, flood diagrams, photo-mosaics, relief models, etc., were in demand. Artillery control points were fixed on both banks of the river. Surveys were carried out to assist the engineer troops who were charged with the erection of permanent bridges as soon as the river had been crossed. The additional strength in mobile reproduction sections with Second Army was found invaluable to deal with the heavy printing programmes. An airborne operation to assist the river crossing in the Wesel area had been planned which involved much careful map supply preparation not only for the initial airborne part of the operation, but also for the subsequent period when the airborne troops would come under the command of a ground formation. For further details about the mapping up of airborne forces *see* Chapter XIV, Section 11.

The crossing of the Rhine and subsequent operations

Enemy opposition to the allied assault across the Rhine was, generally speaking, not so stubborn as had been anticipated. The crossing was successful along almost the entire allied front, and the deep, rapid advance into Germany involved a period of intense activity for the whole survey service.

The speed of the advance made it necessary to review the programmes of new mapping and revision so as to meet the fresh situations that arose almost daily. It was necessary at this stage to arrange with the War Office for the quick production of 1/25,000 maps of Denmark. With the prospect also of the German High Command withdrawing their best formations southwards to the so-called "National Redoubt" in the mountainous area of southern Germany and Austria, and the possibility that forces under S.H.A.E.F. control might reach northern Austria before those coming up from Italy, it became necessary to assemble stocks of maps covering this "Redoubt" area and extending further south into northern Italy. By arrangement with A.F.H.Q. (Italy), the necessary reproduction material was obtained by air from Italy, and production was hastily put in hand by Com. Z. in Paris.

Planning for possible airborne operations during March continued with unabated activity. The mapping up of units, the cancellation of one operation and preparations for another, followed each other in quick succession day after day.

Consideration of survey organization under occupational conditions

It became necessary, at this stage, to make preparations for the survey organization which would be required in Germany under occupational conditions in the event of a German collapse. Establishments were drawn up and preparations included the setting up of a small survey directorate at the London headquarters of the British Control Commission. The printing of German administrative boundary maps, and maps showing the agreed inter-zone boundaries between the allied forces of occupation, was being carried out under S.H.A.E.F. arrangements. Plans were also prepared for the taking over and control of the German National Survey organization, or whatever portions of it might still be in existence.

Investigation of German survey organizations

With the entry of allied forces into Germany itself, arrangements were made for locating, investigating and reporting on the various German survey installations which would be uncovered during the advance. This included survey representation with the appropriate Intelligence staffs at S.H.A.E.F. and allied Army Groups who were organizing "T" (Target) Force parties for exploiting every form of German activity. There was also a special survey investigation party, known as the "Hough" team, which was sent over from the War Department, whose activities were co-ordinated by D. Survey (S.H.A.E.F.) with those of the Army Groups so as to prevent duplication and overlap. Major Hough and his team of experts obtained material of great value.

Mobile map depots with Second Army

For the second time, as the result of a quick break-through, Second Army found it necessary to adopt abnormal map distribution arrangements, the essential point being that the map supply organization must be mobile. This probability had been foreseen, and detailed plans had been made well in advance. Three mobile sub-depots were organized, one being allocated to each Corps H.Q. Each of these consisted of a general field survey section (less draughtsmen), with one storeman, one driver and one 3-ton lorry from No. 3 (Army) Field Survey Depot. Each sub-depot therefore had a total of three 3-ton lorries filled with maps and four 15-cwt. trucks for the transportation of maps and for moving personnel. With their help the quick-moving corps and divisions were supplied successfully with their map requirements.

Preparations for a possible campaign in Norway

With a German collapse in Germany itself a foregone conclusion, there was a possibility that the German High Command might decide to make a last stand in Norway, so as to continue their U-boat campaign as long as possible. Planning for a possible large scale operation was put in hand on the assumption that it would be mounted from the Continent through Denmark and southern Sweden. The whole of Norway might have been involved, and as map provision for that country had hitherto been limited to small areas in the vicinity of

certain ports and large towns, this new possibility entailed an extensive mapping programme with very limited time in which to carry it out. The task for D. Survey (S.H.A.E.F.) was not made any easier by the fact that the planning staff, in their otherwise praiseworthy desire for extreme secrecy, or possibly forgetful of the mapping side of the picture, did not notify him of this new plan as early as they might have done. Every hour was of vital importance, and this omission made the mapping task much more difficult than it need have been. However, as events turned out, the complete German surrender enabled the mapping project to be abandoned, to the relief of all concerned.

The final stages

21 Army Group Survey Directorate moved into Germany during April, accompanied by 515 Field Survey Company, 19 Map Reproduction Section and a detachment of 4 Field Survey Depot. The remaining survey units under direct Army Group control stayed back at Antwerp and Brussels, except for No. 1 (Air) Survey Liaison Section which was with 34 Wing R.A.F. at Eindhoven.

With the clearance of a large portion of north-western Germany, 1 Corps was allotted for an occupational role in Westphalia. A detachment of No. 5 Field Survey Depot was placed under command of Second Army to serve the map needs of this corps.

The speed of movement more or less eliminated the need for field survey for artillery purposes. Even for the Elbe crossing the gunners did not call for any R.E. survey, the existing trig lists having been found adequate. Levelling work was carried out in connection with the establishment of tide gauges on the rivers Weser and Elbe. Demands for defence overprints were considerably less during April but were produced for the Elbe crossing, the investment of Hamburg, and the final clearance of the Cuxhaven peninsula. Towards the end of April, the speed of the advance tended to slacken, and demands for 1/25,000 maps increased.

The first week of May witnessed the final surrender. Increasing pressure had been maintained from all quarters. The final allied offensive in Italy led to the surrender of all German and Italian forces in that Theatre. Berlin was occupied by the Russians on 3rd May, and on 5th May all German forces in north-western Germany surrendered, including those in Holland, Denmark, Heligoland and the North German islands. In the south Sixth U.S. Army Group linked up with the Fifth Army from Italy at the Brenner Pass, and the German forces opposite them surrendered. In north-eastern Austria U.S. Third Army, having taken Berchtesgaden, were approaching Linz and Salzburg, the Russians coming in from the east. The collapse was now complete, and on 7th May German representatives signed surrender terms at S.H.A.E.F. Headquarters in Rheims.

The surrender of German forces in Norway brought into action operations "Doomsday" and "Apostle," whereby an Allied occupational force moved over from Scottish Command to take over the surrender and temporary control of the country. Arrangements had been made for a long time whereby this force would be mapped up by the A.D. Survey, Scottish Command (Lieutenant-Colonel R. H. Denniss, R.E.). The latter, with a small survey directorate, accompanied Force Headquarters to Oslo, and remained there to look after their map requirements and to investigate German survey resources and records.

S.H.A.E.F. opened up a forward H.Q. at Frankfort towards the end of May,

and an advanced map depot was installed there, the Survey Directorate following in about mid-June. It was now a question of tidying up and preparing for occupational tasks. Provisional instructions were issued by S.H.A.E.F. regarding post-hostilities mapping programmes, control action regarding the German Survey Service, and other matters.

A final conference was held by D. Survey at S.H.A.E.F. early in July, attended by the Director of Military Survey (War Office), D. Survey 21 Army Group, and senior representatives of the American and French survey organizations. Preliminary details were arranged regarding subsequent mapping and revision programmes, and other survey matters under occupational and control conditions.

The Survey Directorate at S.H.A.E.F. was officially disbanded on 30th June, 1945. H.Q. British Second Army dissolved at the same time, and early steps were being taken to tranship American forces for further action in the Far East.

The allied survey organization in Western Europe at the close of hostilities is shown in skeleton form in Diagram 7. The total resources in allied survey personnel under the general control of the Survey Directorate, S.H.A.E.F. amounted to approximately 550 officers and 10,000 other ranks.

SECTION 2. MAPS AND MAP PRODUCTION

(A) MAPPING IN THE UNITED KINGDOM

Historical background

The threat of a German invasion of Great Britain following the evacuation of the B.E.F. from Dunkirk made it necessary, for a time, to concentrate practically all available mapping resources on the urgent task of producing maps for home defence. As soon, however, as that requirement had been fulfilled G.S.G.S. took action to provide for actual and potential mapping requirements for overseas operations. Whatever might happen elsewhere it was an axiom of British policy, ever since Dunkirk, that, at some future date, a return would be made to the Continent for the ultimate defeat of Germany. The entry of the United States into the war at the end of 1941 strengthened this policy and hastened the likelihood of its achievement and, though there was some difference of opinion about when the opening of a "Second Front" would be feasible, it was agreed that the defeat of Germany in Europe should have priority over the concentration of resources to defeat Japan.

This policy of an ultimate return to the Continent made it necessary from an early date to consider what mapping programmes would be required for operations in western Europe and to take early action to begin work on this project.

Mapping organization and control

The responsibility for the initiation and control of mapping programmes for operations in Western Europe was, by agreement with the War Department, Washington (*see* Chapter IV) in the hands of G.S.G.S. (War Office). Since the outbreak of war G.S.G.S. had under its technical control the full productive resources of the Ordnance Survey. It also had its own map production and

printing installation which, during 1940 and 1941 and part of 1942, was located at Cheltenham. When G.S.G.S. moved from there to Eastcote in the summer of 1942 this installation was greatly enlarged and became the War Office Survey Production Centre (S.P.C.), located at Hanwell. Some organizational features regarding the work of the Ordnance Survey and the S.P.C. during the war are discussed elsewhere under "Map Production in the United Kingdom." (See Chapter XIV, Section 1.)

Further mapping resources during the preparatory planning period were provided by the military survey organization with Home Forces including a survey directorate at G.H.Q., a small directorate at the headquarters of each Command, and a small number of field survey companies R.E. The Canadians also had their own survey directorate and field survey company R.C.E., which later was expanded to three companies. This survey organization with the Home Forces was expanded between 1941 and 1943 until, about the middle of 1943, 21 Army Group was formed consisting of the British Second and Canadian First Armies. The majority of the survey units which had served with Home Forces were transferred to 21 Army Group, and further units of various sorts were added, such as Map Reproduction Sections, General Field Survey Sections, Air Survey Liaison Sections, etc. This provided a considerable source of strength to map production facilities in the United Kingdom before "D"-day, and subsequently overseas.

Meanwhile American forces had been building up in the United Kingdom including topographical units, and in early 1944 S.H.A.E.F. was formed with its own integrated Survey Directorate. This latter exercised a general control over all allied mapping and survey activities in western Europe and maintained close and constant touch with the War Office with regard to mapping policy and requirements.

During the planning and preparatory period for "Overlord," apart from the time necessary for essential military and technical training, the whole of the resources of military survey units in the United Kingdom were made available to assist in map production for the forthcoming operations. Certain mapping tasks, forming part of the general map production programme, were allotted to these units, with target dates for completion, and without their help there would have been little in the way of 1/25,000 maps available for the initial operations in Normandy and other parts of northern France.

Map production conferences

In order to co-ordinate and control the mapping programmes and available resources, regular map production conferences were held by Brigadier Hotine, the Director of Military Survey at the War Office. These were normally held at fortnightly intervals, and were attended by representatives from G.H.Q. Home Forces (and later from S.H.A.E.F. and 21 Army Group when they were formed), from the U.S. forces and from the Ordnance Survey which was doing much of the productive work under War Office technical control. The conferences were invaluable. They enabled all concerned to be kept informed of the progress of the various map series under production, the build-up of the survey organization and its equipment, and afforded an opportunity for those attending to exchange views, offer suggestions, and discuss technical methods and other problems. Full minutes were kept which were circulated to all those concerned in the United Kingdom and to Directors of Survey in overseas theatres.

Mention should be made of the value gained by the regular attendance of Colonel H. Milwit, the chief survey representative of the U.S. forces in Europe. His ready co-operation and skilled technical knowledge were at all times an invaluable aid to the British military survey service, and he not only undertook a considerable amount of mapping work with his own units, but also acted as intermediary on many matters between the War Office and S.H.A.E.F. and the U.S. mapping organization in Washington.

Map series available in 1940

The only British military maps of France and Belgium available at the time of the Dunkirk evacuation were (*see* Chapter II, Section 2 and Plates 1-5):—

- 1/250,000. GSGS 4042. A 9-sheet series covering Belgium and part of north-eastern France.
GSGS 2738. A 16-sheet series covering northern France to the west and south of GSGS 4042.
- 1/50,000. GSGS 4040, covering Belgium and part of north-eastern France.
GSGS 4040 A, overlapping the above and extending westwards to about Le Havre.
- 1/25,000. GSGS 4041, covering approximately the same area as GSGS 4040 (above).

A small amount of patchy revision data for the above had been accumulated by the B.E.F. and sent home to the War Office. It will be realized, however, that, with the German occupation of the whole of the coastline in north-western Europe, the above limited map coverage was quite inadequate for any future operations that might take place on the Continent.

Strategical considerations

Until such time as precise plans could be drawn up for an invasion of the "enemy-held" coast, it was necessary for the Geographical Section to use its own judgment and intelligent anticipation about what mapping work should be undertaken. As soon as the imminent threat of enemy invasion had passed, G.H.Q. Home Forces started to plan for raids on the enemy coastline, and this entailed the preparation, under high security conditions, of special large scale maps of selected areas. These were produced mainly from air photographs by the Home Forces Survey Directorate and its units.

During the summer of 1942 the C.-in-C. Home Forces was directed to consider plans for an assault operation on the enemy-held coast as an opening bid for the final defeat of Germany in Europe. A small planning staff was set up, and it was early appreciated that the probable locality for the actual assault was limited, for various reasons, to that part of the Normandy coast lying between the Cherbourg peninsula and the mouth of the R. Seine.

As an early measure G.S.G.S. had put in hand the overhaul and revision of the existing B.E.F. map series referred to above but, when a clearer picture was available from the planning forecasts, it became possible for G.S.G.S. and the Director of Survey, Home Forces (and later S.H.A.E.F. and 21 Army Group) to plan new mapping programmes on a priority basis to cover all probable operational areas. As planning became firmer and more detailed it was possible to obtain a forecast of how the initial operations might develop subsequent to the invasion assault, and what would be the most probable axes

of movement. This enabled the mapping programmes for the inland areas to be planned in proper sequence.

In brief, the task confronting the survey service was to provide map coverage on all essential scales for the allied forces likely to take part in operation "Overlord" more or less in the following order of priority:—

The Normandy coastal area and inland as far south as the R. Loire (inclusive).

Brittany.

North-eastern France and Belgium on a central axis running approximately from Paris towards Brussels and Antwerp.

Holland.

The Atlantic seaboard of western France.

Germany, as far east as approximately Berlin, where it was anticipated that the Western Allies and Russia would make contact.

Denmark and parts of Norway.

This left the whole of central, eastern, and southern France more or less unmapped for the time being though there arose later on a priority requirement for south-eastern France in connection with a planned assault operation mounted from the Mediterranean, whereby an allied force would land in south-eastern France and move northwards to join up with the "Overlord" forces under General Eisenhower. The mapping arrangements for this were co-ordinated between G.S.G.S. and the Survey Directorate at A.F.H.Q.

Although, by agreement with the United States, the European theatre fell within the War Office sphere of mapping responsibility, it is pleasant to record the great amount of help and assistance which was rendered by the A.M.S. in Washington during all stages of the preparations for and the execution of operation "Overlord." There was the fullest and happiest co-operation between the British and American mapping authorities and, not only did the Americans print very large stocks of maps, but they also undertook the compilation and drawing of several large blocks of sheets which were allocated to them as part of the general programme.

Some of the principal mapping tasks which were undertaken under G.S.G.S. control, and by survey units in the United Kingdom in preparation for "Overlord," are discussed hereunder.

France and Belgium

(a) 1/50,000.

- (i) *GSGS 4040 (North-eastern France and Belgium)* (Plate 36). During 1941, G.S.G.S. directed the Ordnance Survey to take up the systematic overhaul and revision of this existing series, using whatever air-photos and other revision material could be obtained. During the course of this work the overlaps between sheets were eliminated, thus reducing the size of the sheets so that they could be printed, if necessary, on the demy-size mobile machines in the field, or printed two up on the larger machines. The sheet-lines remained on a grid-line basis. This work, which was much hampered by the lack of photos of suitable standard, continued until 1944, many sheets being revised three or four times as more photography became available. Road and track classification was

carefully examined, and action was taken as a result of previous adverse comments on the series, which criticized the omission of detail of tactical importance. This series was extensively used by allied forces during the pursuit of the German armies through north-eastern France and Belgium in 1944 and subsequent operations in, and occupation of, that area.

- (ii) *GSGS 4040 A and B.* GSGS 4040 A, which was one of the 1939-40 B.E.F. series (Plate 4), did not extend further west than the mouth of the R. Seine. When it became clear that the whole of Normandy and Brittany were likely to be operational areas, sheets were produced for these extended zones in the same style as 4040 A by direct enlargement from the French 1/80,000 map, and they were gridded with the appropriate Lambert grid. As there was also the possibility of operations being undertaken down the Atlantic coastline, a narrow strip along that coast was covered by similar-style sheets.

These 4040 A and B sheets served as a "stop-gap" until they were superseded by a newly drawn 1/50,000 series (GSGS 4250), which is referred to below. They served also as a stage in the production of this new series. Like the original 4040 A sheets they were printed in black only, with coloured grid figures, and were difficult to read in hilly country where the hachures tended to swamp the rest of the detail.

- (iii) *GSGS 4250 (North-western and western France).* Production of this new series was started late in 1941 by the Ordnance Survey and continued right through to 1944 (Plate 37). By "D"-day the sheets of the Normandy area had just been completed in time. The series covered north-western and western France, replacing the series 4040 A and B.

The French 1/80,000 map in its enlarged form (*see above*) formed the basic material, and the sheet lines followed those of the French national series. In the new drawings, revision was incorporated from air-photos wherever they could be obtained. At the start of the series only very haphazard and rather inferior photographic cover was available from reconnaissance sorties and the revision was therefore patchy and incomplete. Later, when a more systematic programme of survey photography was undertaken for the large scale mapping they, and the new 1/25,000 maps, were used to improve further these 1/50,000 sheets. The uncertain and long-delayed supply of the right type of air-photos, however, added very considerably to the difficulties and delays of completing the sheets which were so urgently required, not only for the actual operation, but also for the preparatory planning.

Some of the sheets contained inaccurate detail, and the contouring, being dependent on a somewhat free interpretation of the French hachures, left a good deal to be desired. The map was designed with an eye to rapid production by a somewhat inexperienced drawing staff, many of whom had recently been recruited and had undergone only a superficial training. To save time it was also decided that the same drawings should serve for both the 1/50,000 and 1/100,000 series. For that reason the drawing

was on an intermediate scale, the manuscripts being enlarged up for the former scale and reduced for the latter. Roads were shown by single red lines of varying weight, and contours were at first broken down through a screen so that they could be printed in half-tone from the black plate. This was unsatisfactory, and they were then printed as continuous lines in grey. The green and black circle symbols for woods and orchards were heavy and clumsy, and the lettering for the place-names was a weak feature, the positioning in many cases being ambiguous. There were also many spelling mistakes.

Priority was given to sheets covering Normandy, then Brittany and the western coast. Those required for the actual invasion area reached the winning post of completion just a short head in front of the operation itself.

In the north-east the sheets of GSGS 4250 overlapped those of GSGS 4040 covering north-eastern France and Belgium, and the index layout provided a straight-line junction with another 1/50,000 series (GSGS 4471) covering eastern France.

Generally speaking, GSGS 4250 was not a very good or satisfactory map either in design, appearance or accuracy.

- (iv) *GSGS 4471 (Eastern France)*. When the French started the production of their modern (post-1914–18) map series on 1/20,000 and 1/50,000 scale, they gave priority to their eastern frontier zones. By 1939–40 there were a number of sheets on both scales available in eastern France adjacent to the Italian, Swiss and German frontiers, and extending also along the south coast as far west as Marseilles.

When, therefore, there arose the possibility of allied operations in southern France, it was necessary to take up the production of a new 1/50,000 series for allied use, and this was to be based, wherever possible, on modern French mapping material. Where they existed the French 1/50,000 maps were reproduced by facsimile copying using colour-separation methods (Plate 38). In some cases new compilation was possible from 1/20,000 sheets, where maps on 1/50,000 scale had not yet reached production.

Revision was incorporated from air-photos, and the old French 1/80,000 map was not used as basic material in this area except where it could be supplemented by good air-photo cover. It is interesting to note that the work of producing new sheets was carried out simultaneously in the United Kingdom, at Washington, and at A.F.H.Q. Immediately a sheet had been completed reproduction material was circulated by air so that printing could be undertaken wherever required.

- (b) 1/100,000. No maps on this scale were provided for use by the B.E.F. After Dunkirk, when the British Army was being reconstituted and trained in the United Kingdom, it was decided that, to cater for the rapid movement of armoured forces, a map on the 1/100,000 scale was desirable. For training purposes in England a special edition of the Ordnance Survey $\frac{1}{2}$ -inch map was issued, and consideration was given to the preparation of 1/100,000 maps for future operations in Europe.

As a result, the following were put into production to cover France and Belgium:—

- (i) *GSGS 4336 (North-eastern France and Belgium)*. A series of 21 sheets had been published by the War Office during the 1914–18 war. It had been compiled from French 1/80,000 and Belgian 1/40,000 maps, and the printing plates and other reproduction material were still available. As revision from air-photos and modern French and Belgian maps was being undertaken for maps on larger scales, the same material was used for revising the 1/100,000 sheets. Railways and roads received special attention, the roads being classified according to the standard French and Belgian width categories.

On the whole this was a clear and legible map and was found satisfactory in use. It was published in Army/Air style with purple layers (Plate 39).

- (ii) *GSGS 4249 (Plate 40)*. This series eventually covered the whole of France except for the small part in the north-east which was already covered by *GSGS 4336* (above). The details and design for this map were settled in November, 1941, simultaneously with the beginning of the new 1/50,000 series (*GSGS 4250*). Each sheet embraced an area covered by six of the 1/50,000 sheets and, where those of the latter scale were in production, the same drawings were used for both series. For the smaller scale, however, the footpaths and some of the names of minor villages and hamlets were omitted so as to avoid overcrowding.

The method of preparation varied. The majority of the sheets were based on the French 1/80,000 map, but where good modern French 1/50,000 maps were available in the eastern frontier zones they were used as basic material and, in the north and south-east, where new 1/25,000 maps were being compiled from air-photos, they also were made use of.

A large block of sheets in central and southern France was allocated for production to the A.M.S. in Washington. Though working to the same specification, there was naturally some difference in the appearance of the finished products owing to slight variations in cartography, lettering, etc. The British-compiled sheets were drawn and reproduced at the Ordnance Survey.

The series was published in Army/Air style. Speaking generally it was not a satisfactory map. The topographical detail was indistinct and difficult to read, it had the appearance of being fussy and overcrowded, and was not nearly bold or crisp enough for use, as it had been intended, by crews inside a tank doing their map-reading under difficult conditions.

- (c) 1/250,000. The same two series covering parts of France and Belgium which had been used by the B.E.F. in 1939–40 were again published for use by allied forces during operation “Overlord.” Extra sheets were added to cover the probable extended area of operations and all sheets were subjected to revision and other alterations. Work on them was started in April, 1942.

- (i) *GSGS 4042 (North-eastern France and Belgium)* (Plate 41). This series, consisting originally of nine sheets, was extended to the north so as to cover Holland, and all 11 sheets were revised from air-photos and from other material which was being used for the revision of the larger scales. Communications were brought into line with the latest available information. For France the road classification followed that shown on the Michelin road maps, but for Belgium and Holland the road systems were classified into width categories from modern road maps and from Intelligence reports, many of which were of doubtful accuracy.

The series was published in Army/Air style.

- (ii) *GSGS 2738* (Plate 42) covered the remainder of France lying to the west and south of *GSGS 4042*. Sheets covering northern France had been originally published during the 1914-18 war, and were used by the B.E.F. during 1939-40. These were revised, and the series was extended by the production of new sheets covering the whole of central and southern France. These new sheets were gridded with the appropriate Lambert grid and, in the case of the old sheets, which used to carry a system of reference squares only, the lines were deleted and the Lambert grid substituted. The original design and drawing of the series were not conducive to the production of a pleasing or satisfactory map. The new sheets were an improvement on the old with regard to clarity and appearance.

(d) *1/25,000 and larger scales.*

- (i) *General considerations.* Continued progress and development in artillery technique, radar and other modern devices made it essential to ensure that all probable operational areas in western Europe should be covered by good, accurate maps on 1/25,000 scale. The certainty also that the final battles on the Continent would be preceded by an assault on the enemy-occupied coastline made it all the more necessary that at any rate the mapping of the actual coastal area of the invasion zone on this scale should be completed in good time. This would provide suitable mapping material for detailed planning and other purposes.

In June, 1940, the only 1/25,000 map series available for France and Belgium was *GSGS 4041*. This 1939-40 series (Plate 5) covered all Belgium but only a small part of north-eastern France, not even reaching the coastline in the Pas de Calais. Over the rest of France there was no large scale mapping material other than a relatively small number of modern 1/20,000 sheets which the French had published along their eastern frontier zone, and a few odd sheets covering Paris and some of the principal naval bases such as Cherbourg, Brest, etc.

The problem was therefore a big one. It entailed not only the revision of all the existing sheets of *GSGS 4041*, but the production of a large number of new ones to cover the initial operational areas in north and north-western France, and extending southwards as far as the invasion operations were considered likely to develop during the early stages.

It was clear that such a task would involve the accumulation of

a mass of compilation material including air-photos, considerable resources in skilled man-power and a great deal of time. It was necessary, also, that an early indication of priority areas should be given so that the most vital areas could be completed first. This implied a close and harmonious link between the Director of Survey concerned and the planning staff.

In May, 1942, the Ordnance Survey was directed to revise the existing sheets of GSGS 4041 (Plate 43). Responsibility for the production of the new 1/25,000 mapping was allocated to the Director of Survey, Home Forces, who was best able to keep in close touch with the planning, and who had at his disposal a number of field survey units.

It was obvious that, as there was no suitable French mapping material on large scale covering the proposed invasion zone, air photography would be required, and for this class of accurate work the photos would have to be specially flown to the high specification necessary for survey purposes. With regard to the compilation of the maps, though a certain number of the survey unit personnel had received some training in air-photo mapping, they were not all experts, and there were sure to be a large number of "teething" troubles. Apart from any other considerations, there was no doubt, however, that the proposed programme would provide excellent training in air-photo mapping work for the survey units in preparation for the demands which it was certain would be made on them when they went overseas.

- (ii) *Some early large scale mapping tasks.* Before we consider details of the systematic 1/25,000 mapping programme of the invasion area, reference should be made to various large scale maps of a special nature which were undertaken for G.H.Q. Home Forces between 1940 and the time when intensive planning started for "Overlord." The following are typical examples:—

Calais-Gris Nez area.

When enemy heavy guns were installed on the French coast opposite Dover and the British heavy guns were mounted on the Kentish coast, there was a demand for a large scale gridded map of the Calais-Gris Nez area so that, by fixing the positions of our own and the enemy gun positions on the same grid, effective counter-battery fire could be carried out. In this connection a modern geodetic survey connection between the British and French coasts was observed (*see* Section 3).

The mapping work was undertaken by the 1 Canadian Field Survey Company R.C.E., and was the first air-photo mapping task carried out by this unit after its arrival in the United Kingdom. The only survey material available consisted of medium and small scale maps and charts, the co-ordinates of some French trig points, and some air photographs which had been taken for reconnaissance purposes only and were not nearly up to the high standard necessary for accurate mapping. At that date no proper survey photography had been carried out.

Planimetric control was based on the positions of plotted trig points, but the only height control was that provided by contour heights taken from smaller scale maps where the contours crossed main roads, railways and canals. On this shaky control the contours were then sketched in by stereoscopic examination of the air photographs.

The equipment available to the Canadian Survey Company at that time was somewhat rudimentary but the experience gained enabled them to plan many improvements in technique and apparatus. When the sheets reached the compilation stage they were sent to the Ordnance Survey where the fair-drawing and reproduction were completed.

It is interesting to note that this small drawing section forming part of 1 Canadian Field Survey Company was the nucleus of what was later to become the large and highly efficient Canadian Air Survey Company, equipped with Multiplex plotting apparatus and other photogrammetric equipment, which carried out such a large amount of air-photo mapping both before "D"-day and also with the Canadian Army overseas from the Normandy bridgehead right through to Holland and Germany.

Pas de Calais coastal series (1/12,500).

The next air-photo mapping task undertaken by the Canadians was a series of maps at 1/12,500 scale extending down a narrow coastal strip of the Pas de Calais from Boulogne southwards. These were produced during 1941-42 at a time when there was a likelihood of coastal raids being undertaken along that part of the French coast. The conditions of supply and the quality of the air-photos and other material for this job were similar to those for the Calais-Gris Nez maps. A revised edition was later issued when better-quality photos were obtained.

French coastal series (1/25,000).

During the early part of 1942, at a time when a return to the Continent was in its earliest stages of planning, D. Survey Home Forces considered it was desirable to produce a series of 1/25,000 maps covering a coastal belt extending from Calais along to the western side of the Cherbourg peninsula. This had a dual purpose. Firstly it would make sure that there was at least some form of large scale map coverage of the coastline in case of raids or minor operations. Secondly it would provide a practical training exercise in air-photo mapping for those units which would later be engaged in the systematic mapping of the area. The sheet lines, which were on a grid basis, did not conform to any regular arrangement. They were selected so as to cover the whole coastline with the minimum number of sheets and to give the maximum coverage on each sheet inland from the coast.

The sheets were allocated to all the survey units then serving with Home Forces, and the air-photos and necessary control

data were issued to them with a design specification so as to ensure uniformity. The resulting sheets were carried to reproduction stage so that printing could be undertaken in case of emergency, but they were superseded by the later regular series covering northern France. The lessons learnt during this project were of great value.

Channel Islands.

Quite apart from the possibility of allied raids on these islands there was a map requirement for allied occupation in the event of a German evacuation or surrender. Jersey, Guernsey and Alderney were already covered by Ordnance Survey maps on various scales, and these were revised. There was no existing map covering Sark, Herm and Jethou. To meet a possible Combined Operations requirement the Survey Directorate at G.H.Q. Home Forces produced in 1942 a new map on 1/12,500 scale covering these three small islands. Detail was compiled from air-photos and Admiralty charts.

Ushant.

For a planned commando raid on this island a special map was prepared from air-photos by Survey Directorate Home Forces on 1/12,500 scale. The raid did not take place.

Dieppe.

For the large scale raid on Dieppe, Survey Directorate, Home Forces produced a series of maps on 1/25,000 and 1/12,500 scale with enemy defences overprinted covering the town and harbour and the adjoining coastal areas. These were prepared under high security to meet the date originally proposed for the operation. The raid was postponed, and when it eventually took place the enemy defence overprint was brought up to date from the most recent reconnaissance photos (Plate 44).

Other special maps.

For the raid on a German radar station at Bruneval, and for other raids of a similar nature, large scale maps of specified coastal areas were produced.

The printing of these special maps, which were compiled and drawn at G.H.Q. Home Forces, was undertaken under conditions of high security by 523 Field Survey Company R.E. located near Byfleet, Surrey. Its work was of the highest class and, both from the security aspect, speed of output, and reliability, this unit gave splendid service. At a later date this sort of work was carried out under 21 Army Group control by the newly formed 13 Map Reproduction Section R.E. which had working alongside it 9 General Field Survey Section. These two units were later transferred to S.H.A.E.F. for similar duty.

- (iii) 1/25,000 *Series of northern France* ("Benson" series) (Plate 45). This series, which was given the code name "Benson," was planned to cover those probable operational areas in northern France which were not already included within the existing GSGS 4041 series. This latter, as stated previously, covered Belgium and a small portion only of north-eastern France. It did not even extend as far as the coast of the Pas de Calais.

An appreciation of the strategical situation indicated that the priority areas for this new mapping to meet probable invasion requirements were as follows:—

The coastal zone of Normandy, covering the proposed invasion bridgehead area.

Brittany.

An extension of the Normandy coastal zone southwards to the R. Loire.

An extension of the existing GSGS 4041 series to the west and south-west to cover the Pas de Calais and to join up with the new mapping of Normandy.

The Director of Survey Home Forces, who assumed responsibility for the control and supervision of this project, prepared a layout and specification, and allocated blocks of sheets to field survey units for execution.

The "Benson" programme included an extension of GSGS 4041, and two new areas to which were given series numbers GSGS 4347 and GSGS 4365.

GSGS 4347 covered most of Normandy and Brittany, extending south as far as the junction between Lambert Grid Zones I and II.

GSGS 4365 extended the above map coverage southwards within the limits of Lambert Zone II, but only over the western half of France.

All sheets of the above series were made up on grid sheet lines and measured 15 kms. by 10 kms.

(The remainder of France to the south and east was to be covered by another new series, GSGS 4411, which was not part of the "Benson" project. The sheets of this were to conform to the sheet lines of the new French 1/20,000 mapping, some sheets of which already existed in the eastern frontier zones. Where the latter sheets existed the new sheets of GSGS 4411 were made up by facsimile copying from the French material. For the production of new sheets of GSGS 4411 priority was given to the area in south-eastern France where it was planned to carry out an allied assault operation mounted from the Mediterranean (operation "Anvil"). This work was done by arrangement between the War Office, A.F.H.Q. and the A.M.S. in Washington.)

For the planimetric control of the "Benson" area French trig lists were available. These were based, so far as north-western France was concerned, on records of an old French triangulation and, as many of the listed points were church spires and other prominent features, it was hoped that they would be identifiable on the air-photos. Generally speaking this turned out to be the

case, but there was always some doubt about the accuracy and validity of the co-ordinate values, and a certain number of churches had obviously been rebuilt in different positions since the date of the original triangulation.

For height control there were a limited number of spot heights available from the 1/80,000 map at cross-roads and other identifiable places. The lack of an adequate height control was a source of much trouble.

The arrangements for obtaining survey photographs are described in Section 4. Those provided by the R.A.F. (140 Squadron) were mostly flown by Spitfires equipped with a 12-inch Fairchild camera. Flying at an average height of between 25,000 and 30,000 feet this produced photos at a convenient scale for compilation.

To provide a central control organization, an air survey group was formed in April, 1942, consisting of six newly raised General Field Survey Sections R.E. Its task was to assemble all the photographs and trig data necessary for the work, and to carry out the plotting and adjustment of the control before the compilation of detail could be undertaken by the survey units.

The area to be mapped was divided up into blocks of 25 sheets. For each of these blocks the air survey group prepared a large paper-mounted board of plywood on which the grid was carefully drawn. The trig points were plotted on this grid and the minor control plots for each photographic sortie were transferred to the board and the necessary adjustments carried out. Lists were prepared giving the measured co-ordinates of all the control points so established.

To each of the survey units then serving with Home Forces, including the Canadian Field Survey Company, was allotted one or more of the 25-sheet blocks, and the air survey group passed to them the photographs, control data, and other information which they required for the compilation of detail and contouring. The units undertook the fair-drawing, and carried the sheets through to the reproduction stage including the preparation of kodak negatives for outline, water and contours. Soon after the start of this project the mapping company of 660 Engineer Topographical Battalion (U.S. Army) reached the United Kingdom and was installed at Kew, Surrey, very convenient of access from G.H.Q. Home Forces, then at St. Paul's School, Hammersmith. This unit took over a share of the new "Benson" programme and, as their resources increased, further blocks of mapping were assigned to them.

In the early stages the air survey group carried out the minor control plotting by the "Arundel" radial line graphical method but, as soon as it was possible to obtain sets of the "slotted template" equipment, such as was used by the American units, this latter method was adopted thus improving both the speed and accuracy of the work.

The inadequate height control made it very difficult to provide the survey units with accurate data for contouring. The air survey group tried various methods of overcoming the problem including

the use of stereo-comparators, but the situation always remained unsatisfactory.

Lack of camera equipment with units at that time influenced the decision that fair-drawing should be done on translucent kodatrace on the final scale of reproduction, so that printing plates could be made by direct-contact exposure from the original. Difficulties were encountered owing to the flaking of the drawing ink from the kodatrace. Various expedients were tried, including the use of photopake as a drawing medium, but this was not satisfactory. The American unit, which was extremely well equipped for all types and stages of mapping work, made the fair-drawings on white board which were then photographed in the normal way.

660 Engineer Topographical Battalion was equipped with Multiplex stereographic plotting apparatus but, as the use of this required photographs specially taken with a particular type of 6-inch camera, and as the only photos available at that time were those provided by the R.A.F. taken with a 12-inch camera, plotting with the Multiplex equipment in those early days was not feasible for the "Benson" mapping.

A simple design was specified for the fair-drawing so as to produce clarity, speed of production, and economy of printing. The original specification provided for 3-colour printing in the field, all detail and names being in black, water in blue, and contours in brown. For each sheet, therefore, three separate kodaline negatives were necessary and, as these had to be true to size so as to give good registration between colours, it was essential to use topo-base film which was reputed to hold its shape and size.

Roads were shown by single lines of varying widths depending on their classification. Tracks and footpaths were included; so also were hedges, walls and other field divisions. Although these fully detailed 1/25,000 maps were produced primarily for artillery use, the infantry and their supporting tanks found them to be invaluable in the close "bocage" country of Normandy. There had been some divergence of opinion regarding the showing of hedges and field divisions but the British viewpoint, which was fully confirmed during actual operations, was that the inclusion of this close detail was essential in spite of the extra time required for its compilation.

The existence of more than one grid system in France added certain complications, and it was peculiarly unfortunate that there should have been a change of grid just at the eastern end of the invasion bridgehead area where it might be expected that heavy fighting would take place. The Nord de Guerre and the Lambert Zone I Grid systems had their junction approximately on the meridian of the Seine estuary. This was unavoidable, so on those sheets which included the grid junction, each grid system was extended over the adjoining one by means of grid ticks marked along the marginal edges of the maps. It was thus possible for the artillery, who might have their gun positions in one grid area and their targets in the other, to work in terms of either one grid or the other. It was necessary to lay down very clear instructions as to the use of

grid co-ordinates so that there should not be any confusion between the two different systems. One sheet contained the tri-junction between the Nord de Guerre, Lambert I and Lambert II Grid Zones, so on that particular sheet there were portions of three separate grid systems.

The production programme for the first priority area covering the projected Normandy bridgehead went rather slower than anticipated and, as no further British units were available to start work on the Brest peninsula area, which had high priority, the task was allocated to Company B (U.S. 660 Engineer Topographical Battalion). To start with they used the R.A.F. 12-inch photos but, with a view to accelerating the work and improving the contouring by the use of their Multiplex equipment, arrangements were made for photography of the area by the U.S. Air Force using the special K-17 6-inch cameras. The area to be covered was a large one and time was very limited, but their speed of production progressively increased, and completion was attained by the target date.

When it was known that further mapping resources were available in the United States for this class of work arrangements were made for an extension area lying to the south of the Normandy project to be undertaken by the A.M.S. in Washington. Photographs, control data and full specifications were flown over and the work was started. Tracings of marginal detail along the edges of adjacent sheets which were being produced in the United Kingdom were also flown over as they became available so as to ensure continuity of topographical detail between sheets.

- (iv) *Photo-maps* (Plate 46). The photo-map was essentially an American product. U.S. topographical units were trained and equipped for their rapid production. For the "Torch" operations in north-western Africa large numbers were made and printed but they were seldom used as their quality was poor and adequate map-coverage was available. The British Army did not like them, and never asked for them or used them.

During preparations for "Overlord," however, the U.S. mapping authorities were of the opinion that, in view of uncertainty of the timely completion of the 1/25,000 mapping programme, it was desirable to cover the vital priority areas with photo-maps which could be produced relatively quickly and would serve as a map substitute pending the completion of the 1/25,000 maps. It was also contended that, as they purported to show all ground detail, they would provide a valuable adjunct to the maps themselves.

An extensive project of over 1,000 sheets, on 1/25,000 scale, was begun in June, 1943, covering the Brest peninsula, and an area lying to the south of the first priority "Benson" area in Normandy, where the topographical maps were not likely to be available for some months. This project was later extended to cover the entire area of immediate operational interest. The goal was to provide 1/25,000 coverage in one form or another to a depth of 100 miles from the coast by the spring of 1944.

Most of the work was undertaken by the mapping company of 660 Engineer Topographical Battalion, but the corps topographical

companies which were arriving from the United States each took their share in the project.

The original photo-maps of the Brittany area were prepared from mosaics laid down on a map control. The French 1/80,000 sheets were enlarged to 1/25,000 and the air photographs, scaled to the map, were stuck down in position. The only photos available at that time were those taken by the R.A.F. using 12-inch Fairchild cameras. Many difficulties were encountered owing to random flight lines, tip and tilt, and gaps between flights. In the summer of 1943 a rectifying enlarger was obtained, and the quality and quantity of the mosaics showed considerable improvement. Photographs were ratioed to slotted template control and the tilt in the original negative was rectified.

The photo-map sheets measured 10 kms. by 10 kms. and were gridded similarly to the regular map series. Important detail such as roads and rivers was intensified on the mosaics before the latter were photographed through a half-tone screen.

The photo-map project in northern France eventually comprised nearly 1,600 sheets covering an area of 63,300 square miles, and involved the use of 32,600 rectified prints.

- (v) *Duplicate negatives and block-plots.* The "block-plot" originated at the battle of El Alamein. A description of its origin and use will be found in Chapter V (p. 64) dealing with the Middle East operations.

When the "Benson" 1/25,000 project for northern France was started, there was some doubt about whether the maps would be completed in time. It was decided, therefore, to guard against such a contingency by preparing a skeleton block-plot for each sheet in the Normandy area, on which the positions of the principal points of each photo used in the compilation would be carefully plotted. At the same time the principal points were marked on each original negative by a small fine cross, and duplicate sets of these marked and numbered negatives were made and issued to each of the field armies together with copies of the skeleton block-plots.

By this means, in the absence of the maps themselves, detail plotting could be done overseas of small areas if the emergency should arise, and counter-battery plots could be built up on the El Alamein pattern.

The principal point positions of the photos were marked and numbered also on the 1/25,000 maps in case it might be found necessary later on to intersect targets located on reconnaissance photographs.

The labour of marking up the negatives, making duplicate sets, and preparing the skeleton plots was considerable. As events turned out the 1/25,000 maps were available in time for the operations and, so far as is known, the duplicate negatives and skeleton plots were never used.

- (vi) *Special mapping for the assault.* This included the following items:—
1/12,500 *Coastal areas.* Some 40 sheets covering specially selected coastal areas were prepared from air-photos by survey units under S.H.A.E.F. control.

1/5,000 Beach maps. These were produced by a combined U.S.-British section under the direct control of A.D. Survey 21 Army Group. The section, composed of one U.S. topographical platoon and one British general field survey section, was located at Kew alongside the U.S. Engineer Topographical Battalion. The maps were compiled from enlargements of the 1/12,500 maps and were revised from the latest large scale air photographs and other material available. They showed beach obstacles, including those under water, cliff heights, nature of sand, etc.,

Operational overprints. Over a period of some months leading up to "D"-day, S.H.A.E.F. Survey Directorate controlled the production of operational and intelligence overprints and other special maps for G-2 (Intelligence) and G-3 (Operations) Divisions of S.H.A.E.F. to illustrate planning and intelligence reports. These overprints showed all known enemy defences and dispositions, beach obstacles, and other information relevant to the planning of the assault (Plate 49).

For the operation itself S.H.A.E.F. Survey Directorate, in conjunction with the Theatre Intelligence Section, produced operational stocks (including a stop-press edition) of overprints showing enemy defences and engineer intelligence information comprising 50 sheets at 1/25,000 and over 20 at 1/12,500 scale.

Special mapping for radar use. Detailed plans at a scale of 1/8,000, with contours at 1-metre interval, were prepared of a narrow coastal belt in the assault area by 660 Engineer Topographical Battalion. These were for use in connection with radar determination of position by craft approaching the coast in fog or darkness.

"Security" edition of 1/25,000 maps for briefing. Second Army survey units prepared a special "security" edition of the 1/25,000 sheets covering the assault areas, with fictitious names and other devices to prevent the actual location from being recognized. These maps were used for briefing purposes immediately before the assault.

Holland

- (a) 1/250,000 (GSGS 4042). To cover Holland at this scale two extra sheets were added to the 1939-40 B.E.F. series. These were slightly different in style from the remainder, but were published, like the others, in an Army/Air edition. Special layers in a greeny-brown tint were used to denote areas below sea level.
- (b) 1/100,000 (GSGS 2541). This series was first prepared during the 1914-18 war from Dutch 1/50,000 sheets, but it only covered the south-west and centre of Holland. For "Overlord" it was revised from modern large scale maps and from air-photos, and it was extended by adding two sheets to cover north-west Holland. Eastern Holland was eventually covered by a new 1/100,000 series of Germany which is described later.

- (c) 1/50,000 (GSGS 4083). This series was copied by photo-lithographic methods from Dutch 1/50,000 maps which were very detailed and highly coloured. The resulting map was fussy and obscure and, in view of limited time and the fact that the 1/100,000 and 1/25,000 series appeared to meet tactical requirements, it was decided to concentrate resources on the revision of the two latter series.

Limited stocks of the 1/50,000 sheets were printed for use by intelligence and planning staffs but the series was not issued for operational use. In July, 1944, the A.M.S. in Washington accepted responsibility for the production of a new 1/50,000 series. This was compiled from a new 1/25,000 series which they also produced at the request of the War Office from recent air photography.

Some captured German 1/50,000 maps of Holland were used by planning staffs in September and October. Some of the sheets were reproduced by 21 Army Group and used during operations.

- (d) 1/25,000 (GSGS 4096). To provide initial coverage at this scale the highly-coloured Dutch 1/25,000 maps were reproduced in black only (Plate 47). The originals being very fully detailed and in colour, the result was difficult to read and was unsatisfactory. These sheets were replaced by a newly drawn series (GSGS 4427) described below.

GSGS 4427, covering the western half of Holland, was produced by the A.M.S., Washington (Plate 48.) It was an entirely new drawing, the detail being taken from the most modern Dutch sheets and brought up to date from air-photos. The resulting map was clear to read and pleasing in style. The eastern half of the country was covered by sheets belonging to the German 1/25,000 series. Though made up on sheet lines of the German series they were drawn in the same style as GSGS 4427 referred to above.

Germany, Austria, Poland and Czechoslovakia

- (a) 1/250,000 (GSGS 4346). (Plate 50.) Apart from the standard map series at 1/M scale and the special air maps at 1/500,000 and 1/250,000 this was the first mapping of Germany to be taken up so as to provide coverage for initial planning. It was followed in due course by maps on larger scales. The production priority naturally flowed from west to east and conformed to the most probable trend of operations after entry into Germany. It was based largely on the German national 1/300,000 map and was produced by photo-lithography from black copies of that map. Various methods were adopted to clean up and clarify the resulting map, and colours were added to roads, woods, water and contours so as to publish the series in Army/Air style. In the extreme east and south-east the series was based on Austrian, Czechoslovak, Hungarian and Polish material. Sheets were on a graticule basis and the British military grid was added. Suitable junctions were effected with neighbouring map series covering Holland, Belgium, France, Italy, Denmark and the Balkans so as to ensure continuity and the avoidance of overlaps. During preparation, revision was incorporated from all available material including air photographs.
- (b) 1/100,000 (GSGS 4416). (Plate 51.) This was a newly drawn map based primarily on the German black 1/100,000 national series which, with

its rather dense detail and hill features shown by hachures, was not an easy map to read, and was considered unsuitable for reproduction as it stood. GSGS 4416 covered eventually a large part of Central Europe, and its production was shared between G.S.G.S. and the A.M.S., Washington, who worked to a common specification drawn up by the former. The new sheets carried less detail than the German originals and were published in colour both in Army/Air style and also without layers to meet a demand for this type. On the whole it was a good clear map, and it was revised from all available sources including revised 1/25,000 sheets, to which reference will be made later.

- (c) 1/25,000 (GSGS 4414). (Plate 52.) Germany had been well surveyed on large scale, and 1/25,000 maps of good quality existed for practically the whole country, the only gap being in the south-east where the Bavarian 1/25,000 series was incomplete. The maps were published in black with a German grid, and record copies were held in the War Office map library. The first task was to photograph the record copies of all sheets up to approximately the meridian of Berlin, where it was assumed junction would be made with the Russian armies, and to prepare kodaline negatives for issue to field formations.

In November, 1943, which was the earliest date by which resources could be spared for the work owing to more urgent commitments, the Ordnance Survey was instructed to undertake the reproduction of the German sheets, numbering approximately 3,000. During the course of this initial work the German grid was eliminated and the British military grid substituted. Marginal notes and data in English were added in place of the German version. Production was limited at this stage to the supply of kodaline negatives for monochrome printing, and the printing of a small stock of 6,000 copies for early planning and other purposes. The production of overprint colour plates (e.g., for roads, woods, water, etc.) for adding clarity to the map was scheduled as a field responsibility. Priority was from west to east with special priority given to those sheets which covered the most likely axes of allied advance into Germany. By October, 1944, first-edition kodalines of practically all sheets had been distributed.

Many problems and difficulties arose during the revision of this first edition. They were principally due to certain characteristics of the original German series and led to much subsequent confusion, uncertainty and extra work.

The large scale mapping of Germany had been undertaken separately by each of the individual states—Prussia, Wurttemberg, Baden, Saxony, Hesse and Bavaria. The Prussian survey was the most extensive of these. Each state produced its own 1/25,000 maps and these were based on the individual state surveys, each on its own geographical origin. Unfortunately, these separate origins were not in sympathy with each other, thus causing discordant junctions between the various systems.

A programme of survey and mapping unification throughout Germany had been put in hand, but this project was not complete by 1939 when war broke out. By that date some of the state series had been wholly converted to the Prussian system which, being the biggest and most important, was accepted as the basic series. In the case of

Baden and Wurttemberg, which were both on the same origin, only a limited number of sheets had been converted to the Prussian system, the remainder still being "State" sheets.

The material available for the initial production of GSGS 4414 was therefore a mixed lot, and sheets belonging to discordant systems fell in a somewhat haphazard pattern over southern Germany, the north being entirely covered by sheets of the Prussian system.

There was no doubt or difficulty about the sheets which belonged to or had been converted to the Prussian system. They were consistent with regard to graticule and detail junction at the sheet edges. But in the case of the Baden and Wurttemberg sheets which had not been converted, the discordance in graticule resulted in either gaps or overlaps at their junction with the Prussian sheets.

During the process of initial production at the Ordnance Survey, these gaps and overlaps were mostly attended to so as to ensure a proper junction of detail, and clear notes were in most cases added to indicate the system to which each individual sheet belonged. There were, however, some failures to do this, involving a good deal of trouble and confusion in the field later on.

The 1/25,000 series of Bavaria, which was incomplete, was on sheet lines quite different from those for the rest of Germany and the sheets were smaller. There was, however, a 1/50,000 series of Bavaria which covered the whole state.

Many of the German sheets were out of date and required revision. As soon, therefore, as the first-edition kodelines had been distributed, revision of the series became an urgent task. The systematic air photography of western Germany had been asked for some months previously and when, after many delays, blocks of photography were beginning to come in, a revision programme was drawn up between G.S.G.S. and the Director of Survey (S.H.A.E.F.). The intention was that the work should be shared between home-based resources (the Ordnance Survey) and the survey organization under S.H.A.E.F. control. One block of sheets in western Germany having been allocated to the Ordnance Survey, S.H.A.E.F. allotted blocks of sheets to British and American survey organizations on an operational area basis, and with due regard to probable operational priority. The British share was controlled by D. Survey 21 Army Group, who sub-allocated blocks to the Second British and the First Canadian Armies. The American commitment was handled by Colonel Milwit, who sub-allocated the work to his base topographical organization and to the topographical units with the U.S. 6th and 12th Army Groups. Some sheets were also allotted to the French. Further details of this revision programme in the field will be found later under "Mapping in the Field."

- (d) 1/50,000 (GSGS 4507). (Plate 53.) It had originally been thought that with maps of Germany on scales of 1/25,000, 1/100,000 and 1/250,000 there would be no need for a 1/50,000 map. Later, it was decided at S.H.A.E.F. that, as the allied forces would fight over France and Belgium on a 1/50,000 tactical map to which they would become accustomed, a similar scale map should be provided for Germany. By this time there was little time available for production.

G.S.G.S. drew up details of design and the O.S. was instructed during the summer of 1944 to start work on the project. The map was to be newly drawn, each sheet covering the area of six of the 1/25,000 series, the revised detail of the latter forming the basic material for compilation. The size of the sheets was selected so that they would fit the U.S. Webendorfer press.

As time was pressing, and as the U.S. base topographical organization in Paris was quickly built up to strength, a block of sheets in southwestern Germany was transferred in October, 1944, from the O.S. to S.H.A.E.F. Another block of sheets in southern Holland was allocated for production to A.M.S., Washington.

Priorities were based on S.H.A.E.F. forecasts of the probable developments of operations in Germany, and the programme had to be amended as the strategical situation developed.

The map was in five colours, and was designed in simple style to facilitate quick drawing and easy printing. The western sheets were ready just in time for the operations leading up to the Rhine crossings, but after that the armies moved so rapidly that production could not keep pace.

On the whole it was a clear satisfactory map without any pretensions to cartographic beauty. In the original specification too many minor tracks of little if any tactical importance were included. This tended to clutter up the map and confused the more important detail. They were deleted.

(e) *Miscellaneous maps of Germany, Austria, etc., produced in the United Kingdom.*

- (i) *Reproductions of existing maps.* Reference has already been made to the newly drawn 1/100,000 series (GSGS 4416) of Germany which was published for operation "Overlord" and which covered most of central Europe. Before that publication G.S.G.S. reproduced several existing national map series so as to ensure the existence of a medium scale tactical map over Germany, Poland, Czechoslovakia and Austria. Some of these, which were eventually replaced by GSGS 4416, are briefly touched on below:—

Germany 1/100,000 (GSGS 4081). This was a direct reproduction, with no revision, from German 1/100,000 originals which were dated about 1935. They were in black, were very detailed, and hill features were shown by black hachures which, in hilly country, overpowered the rest of the detail. They carried a German grid.

Poland 1/100,000 (GSGS 4177). Reproduced direct, with no revision, from Polish 1/100,000 originals which were good clear maps, some in black and some in colour. Most sheets carried the Polish military grid.

Austria 1/75,000 (GSGS 5005). A direct all-black reproduction from Austrian 1/75,000 originals which were fully detailed, with relief shown by contours and hachures.

Czechoslovakia 1/75,000 (GSGS 4060). A direct reproduction, without revision, from Czechoslovakian 1/75,000 maps which were fully detailed, and relief was indicated by hachures

and contours. The reproduced sheets mostly had colour-tints added to clarify the roads, woods, etc.

The Ruhr 1/50,000 (GSGS 4156). The French had published a nine-sheet series covering the Ruhr, based on German 1/25,000 maps. As the Ruhr was topographically a somewhat complicated industrial area, this 1/50,000 series provided a useful supplement to the GSGS 1/100,000 maps of Germany for this vital district, and served as such until the production of the new 1/50,000 map (GSGS 4507) and special larger scale maps of the Ruhr area which will be described later. It was published in colour, but no revision was incorporated and no grid added.

Bavaria 1/50,000 (GSGS 4492). The Bavarian State survey had published a 1/50,000 series covering the whole of Bavaria. As the Bavarian 1/25,000 series was incomplete, G.S.G.S. reproduced the whole of the 1/50,000 sheets so as to ensure complete map coverage at medium/large scale over that area. The Nord de Guerre grid was added, and most of the sheets, which dated from 1930-38, were reproduced for printing in four colours, a few of the older sheets being in monochrome only. Kodaline negatives were produced and distributed to field formations.

- (ii) *New compilations.* To provide large scale maps of the industrial Ruhr area and the River Rhine the following series were published:—

The Ruhr 1/12,500 (GSGS 4525). As it was clear that the Ruhr would form one of the principal strategic objectives in western Germany, and that large scale town plans would be wanted for many of the contiguous towns within that area, G.S.G.S. decided to prepare and publish a special large scale series on 1/12,500 scale in 18 sheets. This would avoid a multiplicity of separate, overlapping town plans. Sheets of the 1/25,000 map were enlarged to the required scale and revised from air-photos. Other information was added from town-plans and other documents, and important factories and installations were annotated. The base map was printed in brown with blue water, black names and certain important buildings picked out in black.

The Rivers Rhine and Main 1/12,500 (GSGS 4517 and 4518). (Plate 54.) The R. Rhine, being the major obstacle to the allied advance into the heart of Germany, offered a multitude of planning problems affecting the assault crossing. To provide as much topographical information as possible in handy form, a series of over 60 sheets on 1/12,500 scale was produced, covering the Rhine from Switzerland as far as Nijmegen in Holland. These, like the Ruhr series, were produced from revised enlargements of the 1/25,000 maps, and in somewhat similar style to the Ruhr sheets. After a first edition they were subjected to further revision and issued in improved form. They were, however, found unsatisfactory by the British and Canadians, partly owing to their being enlargements, and

partly also because the revision material was not of the best quality. A new series, on grid-sheet lines, was prepared early in 1945 by First Canadian Army, covering its own front and that of Second Army.

Denmark

- (a) 1/250,000 (GSGS 4479). This series of three sheets was produced by enlargement and colour-separation from original Danish sheets at 1/320,000 scale dated 1938, after making corrections to certain features such as roads and railways. Roads were reclassified on a width basis and red road-filling overprints were prepared. Green tints for woods and blue for water were added, and railways were emphasized. The sheets were on national sheet lines except that the southern sheets were cut so as to join up with the German series GSGS 4346.
- (b) 1/100,000 (GSGS 4210). This was an unrevised colour-separated reproduction of the Danish 1/100,000 map dated 1927-38, and the southern sheets were cut so as to join up with the German 1/100,000 series GSGS 4416.
- (c) 1/25,000 (GSGS 4554). The production of this series was taken up by G.S.G.S. in March, 1945. Each sheet consisted of two of the original Danish 1/20,000 sheets combined and reduced to the required scale. The work was carried out at the O.S., and kodaline negatives for monochrome printing were distributed to field formations in the normal manner.

Miscellaneous

- (a) *Town Plans.* These may be required for tactical purposes. More often they are needed for administrative use, especially in the case of ports and towns where important headquarters may be established and where extensive billeting, office, and storage projects are involved.

In the case of "Overlord" the requirement was a large one, and it was difficult to draw up a priority list for an extensive programme covering France, Belgium, Holland and Germany. The greater part of the work was completed before "D"-day and first attention was naturally paid to the principal towns in Normandy and the main ports in northern France. The War Office (G.S.G.S.) controlled the programme and carried out much of the work at its own Production Centre and at the O.S. British and U.S. survey units took their share, and the Central Interpretation Unit R.A.F. (C.I.U.) and the I.S.T.D. gave much valuable co-operation and help.

The basis of production varied considerably. In some cases, especially for the larger towns, there already existed plans of varying quality and style. Where copies were obtainable, reproduction was effected by direct photo-lithographic methods and the result was printed in black or in colour.

Some were copied from crude originals, and had no pretensions at being anything other than street diagrams. Many were newly compiled from air-photos alone. Wherever possible, no matter what was the basic material available, the plans were brought up to date from air-

photos and from any other modern intelligence material that could be obtained.

By December, 1943, upwards of 150 town plans had been produced covering parts of France, Belgium and Holland. For Germany there were about 50 plans ready by March, 1944, together with a small number in Denmark, Austria, Czechoslovakia and Poland. Further plans were taken up later as demands became firmer.

From the tactical point of view, perhaps the most interesting were the plans of specified villages and small towns which were produced by G.S.G.S. for airborne operations subsequent to "D"-day. For some time the First Allied Airborne Army, or at least part of it, was based operationally in the United Kingdom where airfield resources were naturally more favourable during the early stages of the campaign. Subsequent to the break-out from the Normandy bridgehead, a large number of airborne operations were planned in order to assist the advance of the allied forces across the Seine and through north-eastern France into Belgium and Holland. For all these operations, which required much meticulous and urgent planning, there were demands for standard tactical maps, including those on the 1/25,000 scale, and also for plans of hamlets, villages and small towns which formed specific objectives of the operation. In most cases there were no existing town or village plans, so they were compiled and printed within a matter of a few hours from air photographs. This work would normally have been the responsibility of S.H.A.E.F. Survey Directorate overseas, but as the operations were being mounted from the United Kingdom and time was vital, the War Office took over the task of production and supply. Large numbers of these urgent plans were produced very rapidly by a special section of the Central Interpretation Unit R.A.F. at Medmenham.

As events turned out, the majority of these planned airborne operations never took place, but their cancellation could usually be notified only at the last moment when it was found that the ground forces had advanced more rapidly than had been anticipated, and the mapping preparations had by then been completed.

- (b) *Through-way plans.* In addition to the normal and more detailed type of town plan there was likely to be a requirement for less detailed plans to enable drivers of vehicles to find their way quickly and directly through towns. They required to be simple in style and of small and handy size. Through-way plans were therefore produced for a large number of towns in the probable area of operations in France, Belgium, Holland, Denmark and Germany. They followed the style adopted by the Automobile Association and were published in small-size pamphlet form.

For France and Belgium the Michelin guide provided just the type of plan required, and for other countries corresponding types of guides were used, the plans being reproduced in facsimile. Much help was received during preparation from the I.S.T.D. and the production was carried out by the survey directorates at G.H.Q. Home Forces and at 21 Army Group.

The approximate number of towns for which through-way plans were produced was as under:—

France (in 6 volumes)	950
Belgium	60
Holland	60
Germany (in 2 volumes)	370
Denmark	140
Austria	20

- (c) *Communications of Europe* (1/800,000). This special series, showing the main road, railway and water communications in western Europe, was prepared by G.S.G.S. from Bartholemew's 1/M map of Europe. Roads were plotted according to their various national systems of road classification. Railways were taken from the official railway maps of the countries concerned, and were amended and brought up to date by the War Office Transportation Section. Waterways were taken from official waterways maps, and classified in terms of the capacity of the vessels that could use them.

In addition to a fully coloured edition showing all the communications separate editions were printed showing the basic topographical detail together with either roads, railways or water communications separately, or in any desired combination.

- (d) *Road maps*. In accordance with British mapping policy British forces had been trained, and were accustomed, to use the standard small scale (1/250,000) map for road transport purposes. American troops, no doubt influenced by common civil practice in the United States, favoured the use of special road maps which, while omitting unimportant topographical detail, concentrated on the representation of all important road features. It was decided, therefore, to provide suitable road maps for use by the allied forces in Europe.

For France, Belgium and Holland a direct reproduction in colour was made by G.S.G.S. of the Michelin 1/200,000 road-map series which already existed. There was thus a close association between these maps and the through-way town plans referred to previously which were based mainly on the Michelin guide.

For Germany there was no Michelin road map in existence before "D"-day. During the planning stage the preparation of a nine-sheet road-map series covering all Germany at the scale of 1/500,000 was undertaken by colour-separation from the German Conti atlas of 1938. This provided a satisfactory "stop-gap," but was not much liked by the Americans who, at a later stage, produced some further road maps which will be referred to subsequently.

- (e) *Gazetteers*. These were published to cover all countries in western Europe which were likely to be operational areas. In most cases they were based on the 1/250,000 maps, and contained the names of all towns and villages appearing on those maps together with their map co-ordinates. Production was shared between the War Office and the Central Interpretation Unit.
- (f) *Guide books*. The Theatre Intelligence Section at S.H.A.E.F. undertook the preparation of a series of pamphlets for northern France which would give, in a condensed form, such information about the character and resources of the towns and countryside as might be required by

the allied forces after landing in Normandy. This included data of an administrative, economic, industrial and topographical nature.

The information was collected from a variety of sources, and the assistance of the Survey Directorate at H.Q. 21 Army Group (later C.O.S.S.A.C. and S.H.A.E.F.) was sought with regard to printing and publication.

There were five volumes, each of which contained a number of pamphlets, each pamphlet dealing with one of the French "Départements" such as the Pas de Calais, Nord, Oise, etc. Each pamphlet contained the following information:—

- (i) A general description of the "département" as a whole with particulars about industry, agriculture, waterways, bridges, ports, water-supply, communications, power-supply, airfields, dumps, etc., illustrated by maps.
- (ii) A write-up of each "arrondissement," describing briefly all towns with a built-up area of over 1,000 inhabitants, and smaller towns of special interest.
- (iii) A detailed note of each town of major importance together with a town plan.

Detailed references, with map indices, of all the standard map series covering the area of each pamphlet were included and, as there were so many town-plans, etc., to be printed, the Survey Directorate agreed to print the whole publication provided the text was typewritten in a form suitable for photo-lithographic reproduction. This was done and the volumes were finally bound and made ready for issue by H.M. Stationery Office.

(g) *Relief models.* By December, 1943, when detailed planning for "Overlord" had been started by H.Q. 21 Army Group, several relief models were available of the invasion beaches and hinterland. These had been constructed by an integrated British-U.S. team of model-makers working at the R.A.F. station at Medmenham.

In view of expanding demands for these models and the limitations of manufacturing resources D. Survey (S.H.A.E.F.) decided to co-ordinate all demands from British-U.S. staffs, who were becoming increasingly appreciative of the value of such aids to planning and briefing.

As time passed, practically all army staffs engaged on planning were demanding some form of relief model, and it became necessary to organize a method of manufacture which would satisfy the requirement. H.Q. 21 Army Group therefore held a conference at which all available aids to planning were on view to potential users. These aids included lantern-slide anaglyphs, the standard "Medmenham" type terrain model at various scales, U.S. Naval rubber-cast models, and a quickly made portable model known as the "egg-box" type which could be made up under field conditions by quickly trained personnel. This latter type was so called because the basic framework of the model consisted of sets of parallel strips of stiff material which fitted into each other at right angles, similar to the cardboard divisions for holding eggs in a travelling egg-box. The top edge of each strip was trimmed to shape so as to

correspond, on an agreed exaggerated vertical scale, with the shape of the ground along that particular section which the strip represented in plan. When all the strips had been fitted together the surfacing material, incorporating a map of the area, was stretched over the top thus giving a representation of the ground in relief.

The egg-box model had been introduced from Italy where it had met with considerable success. As a result of the conference an organization was set up under the general control of the Survey Directorate 21 Army Group to undertake the training of model-making teams. The chief instructor was the U.S. Army officer who had introduced the model from Italy, and the school was accommodated at Chelsea Barracks under conditions of high security. Teams of six workers each, largely from Corps Intelligence Sections (British and Canadian) were trained there and were afterwards engaged on the preparation of models of the beach areas over which their own formations would be fighting. On completion these models were sent to corps, where they were further distributed to lower formations before embarkation. They were also used to assist in detailed technical planning.

For further details regarding relief models *see* Chapter XIV, Section 2.

(B) MAPPING OVERSEAS

Organization and equipment

A summary of the principal mapping work which was undertaken in the United Kingdom for operation "Overlord" has been given in Section A. Much of this was in preparation for the assault, and had therefore to be ready before "D"-day. The completion of further projects to meet allied requirements as they moved eastwards across France and Belgium into Holland and Germany, and further demands from S.H.A.E.F. for new mapping, revision and bulk-printing, kept the mapping resources in the U.K. working at high pressure from "D"-day till the end of hostilities. Resources in the United States were also heavily committed, not only in taking a share of new mapping production, but also in bulk-printing for American forces on the Continent subsequent to the initial stages of the operation.

The general policy was that the War Office and War Department, Washington were responsible for the provision of bulk-printed stocks of small and medium scale maps for their respective forces, and that the allied survey organization overseas was responsible for the revision and printing of all large scale maps, and for the production and printing of any special maps or map-series which were found necessary and had not been provided by the home-based authorities.

Some of the projects for new mapping, revision and printing which were undertaken overseas will now be considered. It was realized that there would be occasions when stocks of medium and smaller scale maps would run short as a result of unexpected high consumption, losses in transit and other causes, and in such circumstances it would be necessary to print extra stocks locally. The printing of large scale (1/25,000) maps, especially in the Normandy bridge-head, was a very heavy commitment. Also the requirements of planning and intelligence staffs and other staff branches were always considerable and

varied. There were many special mapping tasks which had to be undertaken, a number of which were of a day-to-day urgent operational nature, while others were of a more long-term character. Examples of the latter were the administrative boundary maps of Germany which were produced by S.H.A.E.F. Survey Directorate in anticipation of occupational requirements, and which required a great deal of careful research.

Before describing the actual mapping work undertaken it may be well to summarize the principal mapping resources which were available with the Allied Expeditionary Force for new mapping, revision, map production and printing. The number of units given represents approximately the situation towards the end of the war in the spring of 1945. There were, of course, transfers of survey units from one formation to another as demanded by changing situations. See Diagram 7.

(a) *Supreme Headquarters and U.S. Base Installations.*

- (i) *Supreme Headquarters.* The integrated British-U.S. Survey Directorate had under its direct control two small British units for meeting the special mapping requirements of S.H.A.E.F. and for the preparation of certain special maps for general use. This work was controlled by the Mapping sub-section of the Directorate, which maintained close touch with all staff branches of S.H.A.E.F. and the survey branches of lower formations. The planning, intelligence, operations and engineer branches were the most active customers. The units concerned were:—

No. 13 Map Reproduction Section R.E.

No. 9 General Field Survey Section R.E.

- (ii) *U.S. Base survey organization.* This was part of the U.S. Communications Zone organization and was controlled by the Chief Engineer through Colonel H. Milwit (Chief, Intelligence Division). He had at his disposal 660 Engineer Base Topographical Battalion with its survey, photo-mapping and reproduction companies, lavishly equipped for all sorts of mapping work, including Multiplex apparatus for plotting from air photographs. This unit was augmented by 659 Base Topographical Battalion and was installed in Paris where it formed the Engineer Base Mapping Plant.
- (iii) *French "Institut Géographique National" (I.G.N.).* (Service Géographique de l'Armée.) The French National Survey organization, with its headquarters in Paris, somewhat resembled a combination of the British Military Survey Directorate (War Office) and the Ordnance Survey. It functioned also as the "Service Géographique Militaire de l'Armée" and was commanded by General Hurault, already well known to several of the British survey officers. As Paris was in the American zone of operations Colonel Milwit exercised co-ordinating control over the I.G.N. mapping activities, and one of his officers was installed at General Hurault's headquarters for this purpose. General Hurault was in a specially favourable position to requisition aid from several of the civilian printing firms in Paris, and during the course of the war after the liberation of Paris, the I.G.N. provided most helpful co-operation and practical aid.

(b) *British and Canadian Forces.*

21 Army Group.

The Director of Survey, 21 Army Group (Brigadier A. Prain) exercised control over all mapping activities within 21 Army Group for which the following resources were available:—

(i) *H.Q. 21 Army Group.*

- 515 Field Survey Company R.E.
- 14, 15, 16, and 19 Map Reproduction Sections R.E.
- 4 and 5 General Field Survey Sections R.E.
- 1 Air Survey Liaison Section R.E.

(ii) *British Second Army.*

The D.D. Survey (Colonel A. W. Heap) had under his control the following survey units for mapping and reproduction work:—

- 14, 519, and 521 Field Survey Companies R.E.
- 1, 2, and 3 General Field Survey Sections R.E.

(iii) *First Canadian Army.*

- The D.D. Survey (Colonel H. Meuser) had at his disposal:—
- 1 Canadian Field (Air) Survey Company R.C.E., a highly trained specialized unit for mapping and revision, especially from air-photos.
 - 3 Canadian (Reproduction) Survey Company R.C.E., with mobile (demy) reproduction plant.
 - 2 Canadian Field Survey Company R.C.E., principally for field survey but capable of being employed also on mapping work.
 - 30 Canadian Air Survey Liaison Section R.C.E.

(iv) *Belgian "Institut Cartographique Militaire."*

The Belgian national survey organization had been almost completely disrupted during German occupation. Most of their records had gone and only one or two printing presses were still available. Colonel Mary, the Director, was, however, still in Brussels and he gave most valuable co-operation and assistance in enabling D. Survey 21 Army Group to take over the plant of a high-class printing firm in the city. A Map Reproduction Section R.E. was installed at the H.Q. of the "Institut."

(c) *U.S. Forces.* General over-all control of mapping work carried out by American topographical units serving in western Europe was exercised by Colonel Milwit referred to above. Apart from the base units serving directly under his control were the following, which formed part of the various field formations:—

(i) *12th Army Group.* General control of mapping and reproduction work was in the hands of the engineer at Army Group H.Q. who had on his staff a topographical branch headed by Colonel W. D. Milne.

Unlike the British, he had no survey units under his direct control at Army Group H.Q., but he exercised policy-control over the work of the topographical units serving with the following formations (as they existed during the latter stages of the war):—

First U.S. Army.

654 Engineer Topographical Battalion (Army).
663, 665, and 668 Engineer Topographical Companies (Corps).

Third U.S. Army.

652 Engineer Topographical Battalion (Army).
664, 672 and 673 Engineer Topographical Companies (Corps).

Ninth U.S. Army.

655 Engineer Topographical Battalion (Army).
62, 667, and 669 Engineer Topographical Companies (Corps).

Fifteenth U.S. Army.

657 Engineer Topographical Battalion (Army).
524 and 680 Engineer Topographical Companies (Corps).

- (ii) *6th Army Group.* The Engineer, 6th Army Group controlled the mapping and reproduction work of units within the Army Group through his topographical branch (Colonel L. Wirak). The units were as under:—

Seventh U.S. Army.

649 Engineer Topographical Battalion (Army).
661, 666, and 679 Engineer Topographical Companies (Corps).

First French Army. Colonel Recordon, of the Geographical Staff Section at Army H.Q., had under his control the 31st and 32nd Geographical Companies. These units did not receive their mobile printing equipment (U.S. Webendorfer presses transferred from Algiers) until towards the end of the war.

- (d) *Equipment.* The Allied units were equipped for map reproduction as under:—

(i) **BRITISH.**

Field Survey Companies R.E. Each company had as standard two Crabtree full-auto-feed presses (demy-size) mounted in lorries. Photo-mechanical equipment and cameras were also lorry-mounted, and grainer, generating plant and other ancillary equipment were available. Owing to the great amount of 1/25,000 printing that became necessary the allocation of printing presses to these units was practically doubled soon after their arrival overseas.

Map Reproduction Sections R.E. These were equipped with semi-mobile double-demy Crabtree presses (full-auto-feed) on a scale of one single-colour and one two-colour machine to each section. They also had one Baby Mann press for dealing with small jobs.

A static double-demy camera and full ancillary equipment made this small unit capable of turning out rapidly a great deal of useful reproduction work, especially where two such units could be located together.

(ii) CANADIAN.

Though their survey units were organized on a different basis from the British, the equipment available to the Canadian Army was, so far as the mobile units were concerned, similar to that provided for the British field survey companies. They did not have any map reproduction sections.

(iii) U.S.

Base mapping plant. When finally installed in Paris the printing equipment of two engineer topographical battalions was available, together with several other machines of various types belonging to the French commercial printing installation where they were located. The standard equipment of each battalion included four 22" × 29" Webendorfer presses and one 40" × 40" copy camera. 660 Battalion had added six of the British Crabtree presses of the semi-mobile type, four being two-colour double-demy, one single-colour double-demy, and one single-colour quad-crown. Extra camera equipment was also added.

Engineer topographical battalions (Army) and topographical companies (Corps). These units, which formed part of the army and corps organizations respectively, were well equipped with mobile reproduction trains consisting of specially designed lorries in which the equipment was mounted. Originally the printing presses were "Harris" machines which had a maximum sheet size of 20" × 22½" only and cameras of similar small size. As the standard 1/25,000 maps of France were 24½" × 19½" the Harris presses could not print them. On representations being made to Washington, Webendorfer presses (22" × 29") and larger-size cameras were substituted.

(iv) FRENCH.

Details of the map-printing equipment at the disposal of the Institut Géographique in Paris are not known but, with the civilian printing firms which were called on to help, the resources were considerable. The two small field units which served with the First French Army were eventually equipped with Webendorfer machines.

It will thus be seen that the map reproduction and printing resources available on the Continent were extensive.

For map compilation and drawing the American units were more lavishly equipped than the British. Their base and army units had a considerable amount of Multiplex air-photo plotting apparatus and other devices such as rectifying enlargers, etc. The Canadians also had a limited amount of Multiplex equipment and large numbers of air-photo rectifiers for table use. The British units had no Multiplex apparatus and, except for a few "Thompson" stereo-comparators, depended largely on simple table-model stereoscopes for their air-photo work.

Operational mapping during the first phase. (In the Normandy bridgehead, June–August, 1944)

ARRIVAL OF SURVEY UNITS

In accordance with the light scales assault organization one reproduction section and one photo section accompanied each of the Second Army field survey companies which crossed over in successive detachments soon after "D"-day. They were a few days behind schedule, and some of the intelligence overprints and artillery fire-plan maps which were asked for during the early fighting could not be supplied. The balance of the equipment followed as convoy space could be made available. In the American sector of the bridgehead, printing equipment accompanied the First Army topographical units.

Canadian Survey units with their mapping plant followed during July.

1/25,000 STANDARD PRINTING

All survey units had been supplied with kodak negatives of the 1/25,000 "Benson" series of northern France. There was a heavy demand for this large scale map from all arms, and not only from the artillery for whom it had been primarily produced. One main reason for this was that the 1/50,000 maps were insufficiently detailed and too generalized, and they could not, of course, show the hedges and other field-divisions which formed such a vital tactical feature during the close fighting in Normandy.

The accuracy of detail on the 1/25,000 maps was, in general, very satisfactory, though the contouring was found to be inaccurate. This latter defect was owing to the lack of reliable height-control when the series was being compiled.

The printing sections were soon working to full capacity, and both the British Second and First Canadian Armies found it necessary to ask for further printing lorries. This was approved, and their mobile equipment was practically doubled as soon as the extra plant could be supplied. The rapid increase in 1/25,000 printing is shown by the following figures applying to British and Canadian survey units:—

June (part of)	20,000 copies (3 colours)
July	535,000 copies (3 colours)
August	2,575,000 copies (3 colours)

The increasing rate was due to a variety of causes. In June, formations had been well mapped up before the assault, and the printing machines did not begin to arrive in the beach-head till late in the month. In July units were not up to full strength in printing lorries till well on into the month. By August units were printing well ahead of demands (until the break-through and the rush across France overran the maps), and building up stocks.

During July and August the topographical units of First U.S. Army printed 370 sheets of the 1/25,000 map totalling 3,000,000 copies, and Third U.S. Army was likewise fully extended from the moment it reached France.

After the break-out the allied advance became so rapid and fluid that, for a time, the printing of 1/25,000 maps to keep pace with movement was very largely suspended pending some indication that the advance was likely to be held up. In the case of the First U.S. Army, after crossing the Seine the maps were printed in one colour only to save time, the contours being printed in a half-tone from the black plate.

"GOING" MAPS, DEFENCE OVERPRINTS, AND OTHER SPECIAL MAPS

There was an early demand in Second Army for special maps and overprints. "Going" maps in colour were produced, not only to facilitate the planning of armoured movement, but for actual use by tanks in action. By using a blue-grey base, with orange and red overprints in solid and stipples, the various types of "going" were shown, *i.e.*, areas which were impassable, or suitable for armoured movement.

There were also defence overprints, fire-plan traces, traffic lay-out diagrams, and many others. For the defence overprints and fire-plan traces, it was generally found convenient to send a printing lorry on detachment to the headquarters of the corps artillery.

By late August, 21 Army Group Survey Directorate had installed two map reproduction sections in the Caen area, and these were soon working to full capacity on all forms of map printing including standard series to maintain vital stocks, airfield maps, railway, road and soil intelligence maps, and assault traces for the projected crossings over the Rivers Seine and Somme.

The Canadians completed a number of new 1/12,500 sheets from air-photos covering the planned Canadian crossing sites over these rivers, but the rapidity of the advance was such that there was no need for their publication.

U.S. Army units had always been accustomed to the use of clearly annotated road maps and, in July, First U.S. Army produced the first sheet of a 1/100,000 road map of northern France. During August, further sheets were published and nearly half a million copies were printed, but the series was discontinued as soon as the rapid move eastward began. Later on, with a return to more static conditions, there was a renewed demand for road maps for operations in Germany.

Photo-maps had been prepared by American topographical units for large areas of northern France and kodelines of these were carried. A small number were printed during the early operations but, with an adequate 1/25,000 map available, there did not seem to be much demand for the photo-maps even by the Americans, and none were required by the British.

REVISION

One of the first tasks undertaken by Second Army survey units was the road-classification of those 1/25,000 sheets which fell within the occupied bridgehead area. Revision of detail and contours was undertaken with the aid of ground reconnaissance, air-photos, and captured German maps. Progress was slow, and the results, especially those of contouring, were unsatisfactory. It seemed evident that the training of the personnel for topographical work in the field was not up to the desired standard, but this was undoubtedly largely owing to the fact that, since their training courses at the Survey Training Centre, the junior officers and men of the survey units had been almost exclusively occupied on the air survey plotting and drawing of the 1/25,000 maps of Normandy. This work had to be carried out at such high pressure that little if any time was left over for consolidating, much less increasing, their practical knowledge and skill in field topography. The same weakness was noticeable in other theatres, and draws attention once more to the need for intensive practice in plane-table work in the field, combined with the concurrent stereoscopic study of air-photos of the same area. This is surely

the most certain method of producing that "topographical mentality" which is so valuable an asset for a surveyor.

The break-out from the bridgehead put a stop to this revision programme.

The second phase (the advance to the Rhine)

OPERATIONAL BACKGROUND

This second phase included the period of rapid advance through north-eastern France and Belgium, the entry into Holland, the forcing of the Siegfried Line, the cleaning-up operations west of the Rhine, and the preparations for the Rhine crossing.

21 Army Group consisted of the Second British and First Canadian Armies. 12th U.S. Army Group eventually comprised the U.S. First, Third, Ninth and Fifteenth Armies, and, after a successful assault operation in southern France, the U.S. Seventh Army with the First French Army formed the 6th U.S. Army Group. During this period strong base U.S. map reproduction resources were built up in Paris. 21 Army Group installed a powerful group of map reproduction units at Brussels and Antwerp.

In anticipation of a possible early thrust into Germany, attention was naturally focussed on the need for hastening the completion of the standard maps of Germany which were being undertaken in the United Kingdom and in the United States, and the revision of the large scale maps by field formations. There was also the need for the preparation of special maps of all sorts to assist airborne operations, to facilitate the crossing of the Rhine and the cleaning up of the Ruhr, and to indicate all the various zonal and administrative boundaries which would be adopted by the Allies during the occupation of Germany.

The rapid pursuit of the German forces was slowed up in southern Holland, along the German frontier in Belgium and Luxembourg, and in the Saar and Alsace regions of eastern France. This afforded a welcome respite for building up map stocks and the revision and preparation of maps for subsequent operations.

BASE MAPPING ORGANIZATIONS

S.H.A.E.F. and U.S. Communications Zone. By the end of September, S.H.A.E.F. Survey Directorate had joined S.H.A.E.F. (Main) at Versailles, and an advanced party of 13 Map Reproduction Section, with a Baby Mann printing press, was installed in a factory building at Suresnes (Paris) for the hasty production of maps for G-3 (Ops.) and G-2 (Intelligence). The main body of 13 Map Reproduction Section and 9 General Field Survey Section closed down in the United Kingdom on 7th October and was in operation at Suresnes by early November, the transport of the heavy machinery taking some considerable time. These two units served the special mapping needs of S.H.A.E.F. until the close of hostilities, and proved to be a most efficient and happy organization.

Meanwhile E.T.O.U.S.A., which had started to move over to France in August and was redesignated Communications Zone (Com. Z.) for operational purposes, moved into Paris early in September and Colonel Milwit (Office of the Chief Engineer) set up his H.Q. there and installed his base map reproduction plant in the commercial printing works of a high-class French magazine, which were located at Bobigny on the outskirts of Paris. From then onwards D. Survey (S.H.A.E.F.) was able to maintain almost daily contact with Colonel

Milwit for the co-ordination of mapping policy to meet allied requirements within the theatre.

Institut Géographique National (I.G.N.) Immediately after the liberation of Paris D. Survey S.H.A.E.F. and the Topographical Engineer 12th Army Group (Colonel Milne) made contact with General Hurault, the Director of the I.G.N., and arranged for his co-operation and the utilization of his cartographic and printing facilities. Colonel Milne also took over available printed stocks of French maps of the immediate operational area for issue to the American Armies at a time when the supply and distribution of allied map stocks was proving a difficult problem.

Copies of all French map production since 1940 were obtained and sent to the War Office, and arrangements made for a French officer to visit S.H.A.E.F. and take with him all available information on many survey and mapping subjects, including material for Indo-China and other parts of the Far East which might be of value to the War Office.

SIEGFRIED LINE DEFENCES

Copies of French defence overprints of the Siegfried Line were obtained and were delivered to G-2 S.H.A.E.F. for incorporation in S.H.A.E.F. traces of the German defences. Co-ordinated arrangements were then made between S.H.A.E.F. and the War Office for the production of base maps (Germany 1/25,000) and defence overprints covering the Siegfried Line defences, and for the direct delivery of reproduction material to army groups for their immediate use in planning. Just over 100 sheets were required to cover the area of the known defences.

ADMINISTRATIVE MAPS OF GERMANY

In accordance with allied plans for the occupation of Germany S.H.A.E.F. Survey Directorate began the preparation, during September, 1944, of various maps of Germany and Austria to show, in the form of overprints, the various administrative and zone boundaries which would be used in connection with military government and the administration of the country. These included the following:—

- 1/1,600,000 showing German states, provinces, etc., and the agreed boundaries between allied zones.
- 1/1,000,000 showing German administrative boundaries.
- 1/250,000 showing German administrative boundaries.
- 1/200,000 (Berlin) showing districts, and boundaries between the allied sectors.
- 1/16,000 (Berlin) showing district boundaries.
- 1/25,000 (Germany) selected sheets showing in detail the agreed boundary between British, American, and Russian zones of occupation.
- 1/1,000,000 (Austria) showing administrative and zone boundaries.
- 1/75,000 (Vienna) showing administrative and zone boundaries.

The preparation of the above maps involved much detailed research in order to ensure that the most recent and authoritative version of the various boundaries was shown. The work of preparation was undertaken by 9 General Field Survey Section and 13 Map Reproduction Section under the general direction of Lieut.-Colonel J. S. Sheppard at S.H.A.E.F. Survey Directorate.



During September, 1944, preliminary plans and co-ordinated arrangements were made by S.H.A.E.F. with the War Office, Com. Z., and army groups for the revision of the 1/25,000 series of Germany which had been initially produced by the War Office. The War Office took over responsibility for the revision of a block of sheets covering the critical area between the Belgian frontier and the Rhine. Further to the north a block was allocated for execution by survey units at H.Q. 21 Army Group and by Second British Army and First Canadian Army units. Another block in south-western Germany was given to Com. Z. for revision by base mapping units, and by topographical units of the U.S. 6th and 12th Army Groups. The basis for this revision was air photography, and every possible attempt was made to ensure a speedy completion of the photographic programme. All available sources were tapped to obtain suitable photos, but the lack of a firm survey photographic policy at that time, combined with bad-weather periods, caused dangerous and annoying delays.

Towards the end of October, when it seemed evident that the flow of revised sheets from the United Kingdom would not meet the required completion date, S.H.A.E.F. Survey Directorate authorized army groups to undertake their own independent revision, in areas of critical operational urgency, as an insurance against the possible non-availability of revised editions which were being produced at the O.S. It was foreseen that an undesirable situation might arise as a result of having two separate, and possibly different, revised editions produced concurrently, and appropriate steps were taken to meet this situation. All concerned were warned about this, and instructions were issued regarding the adoption of a single operational edition only. As events turned out the sheets actually accepted for use during operations in the extreme west of Germany and in Holland were those revised by survey units overseas. On completion of these early blocks the War Office assumed responsibility for the revision of blocks of sheets further to the east up to and including Berlin. Experience indicated that it is safer and better that the revision of areas of probable early urgency should be carried out by units with field formations overseas rather than by a home-based organization, and for the latter to concentrate on areas further ahead.

The Director of Survey (S.H.A.E.F.) realized the essential need for maintaining a proper and effective control over the preparation and issue of revised editions, and of supplying to all concerned up-to-date information regarding the latest edition of any map. This was perhaps of particular importance during "Overlord" on account of:—

- (a) The large number of potential originators of a revised edition. These included the Survey Directorate (War Office), S.H.A.E.F., 21 Army Group (with, under command, Second British and First Canadian Armies, and sometimes one or two U.S. Armies), 6 and 12 U.S. Army Groups (with U.S. Armies under command each having their engineer topographical battalions and corps topographical companies), and also the U.S. base mapping organization in the Communications Zone.
- (b) The fairly frequent changes of boundary between army groups and armies whereby formations frequently found themselves fighting on maps which had been revised by survey units of other formations.
- (c) The wide-ranging interest of the air forces who, for close support and intelligence photographic purposes, required to use maps on scales as

large as 1/25,000 and even town plans in areas covering a wide range of front and depth.

It was of vital importance that armies, corps, and divisions and the air forces should know about, and be able to obtain, the latest current edition of any maps which they required to use. Also in order to prevent misunderstandings and misinterpretation of orders, reports and telephone conversations, it was important to ensure that all map-users changed over from one edition to another at the same time. It was also desirable that survey directorates should know at the earliest possible moment when a new edition was produced anywhere in the theatre of operations, and should receive a few copies of the newly revised map.

By arrangement with the Survey Directorate (War Office) the revision control of all map series in the theatre except those on 1/500,000 scale and smaller had been delegated to the Director of Survey (S.H.A.E.F.). The latter delegated to army groups the right to change the edition of a map, but only in conformity with a definite procedure laid down by S.H.A.E.F., which would ensure uniformity. Any army group making a change had to notify S.H.A.E.F. and neighbouring army groups that the change was being made and, in the case of sheets overlapping an army group boundary, the army group originating the change had to ensure that the adjoining army group received a printed stock of the revised edition in time to distribute to the troops if operations were involved. In the case of sheets not on the boundary, a small number of copies (25 to 50) of the revised sheets were to be sent to the adjoining army group for early air use. Kodak film negatives of the revised sheets were also distributed.

Army groups themselves co-ordinated the activities of armies under their command in producing new editions, and ensured that stocks of revised maps were available before the change-over was made.

Instructions for the change-over were then issued by the general staff of the army group, normally by signal. This was always confirmed later in army group orders. Copies of the signal were sent to S.H.A.E.F. and to adjoining army groups. The signal specified the date and time at which the change-over would be made.

Shortly after "D"-day, map indices for all the western European map series had been given a wide distribution, with overprints showing the number of the current edition for each sheet. Thereafter survey directorates and other interested parties kept their "Current Edition Indices" up to date. About once a month S.H.A.E.F. published map indices with overprints showing the latest edition numbers which enabled everyone to check up the data. S.H.A.E.F. also issued instructions governing the production of new editions. These rules embraced the following main points:—

- (a) Any but the most minor alterations to the face of a map entailed a new edition number.
- (b) The publication of a new edition automatically involved the destruction of all existing copies of the earlier edition unless specifically excepted.
- (c) Therefore, corrections were not to be made till they were sufficiently numerous or important to warrant the destruction of the old stock.

The above system worked well. Its application was not so complicated or cumbrous as it might appear from the above. It needed good will and careful control by all survey staffs. The principal advantages gained from it were twofold. Firstly it tended to eliminate misunderstandings and errors during operations. These might range from mere inconvenience and irritation to

tactical disaster and serious loss of life. It ensured, secondly, that the revision state of any particular map-sheet was easily and correctly stated, recorded, or ascertained. This was most important, and its importance may well become greater as the capacity of the survey service to produce its own maps in the field increases.

It was necessary also to organize a proper control over the preparation and distribution of reproduction material for the revised sheets. When an army, for example, produced and published a revised edition, complying with the various rules mentioned above, they would make one or possibly two kodamine film negatives of the map for immediate use, but they would not have had the time or facilities to make enough copies of the kodamine for distribution to all the other formations. S.H.A.E.F. therefore arranged a procedure whereby, immediately a new edition had been published, the originating formation sent a master film-positive of the sheet to the War Office. There, by means of a rapid film-processing machine, the required number of film negatives was made for immediate distribution to those formations overseas who already held kodamines of the earlier edition. These formations had, in the meantime, been warned that their existing kodamines were out of date and should therefore be tagged pending the arrival of the new edition. It will be realized from the above how essential it was that "kodamine" record sections should be available at the various Survey headquarters where map revision and other such records had to be kept, where warnings of edition changes originated, and from where kodamines had to be distributed to subordinate formations.

A variety of methods was adopted by the different units for carrying out the revision. The basic material at their disposal consisted of kodamine negatives of the War Office First Edition which had been distributed to all concerned. The revising units were required to produce a kodamine positive incorporating the revision of all detail of tactical importance, with special emphasis on roads and other communications, woods, and built-up areas including isolated buildings. These positives were, as explained above, sent to the War Office, who arranged for the production of kodamine negatives therefrom, which were then distributed to formations overseas in accordance with a scale laid down by S.H.A.E.F.

Several of the problems which arose in connection with the revision of this series have been described in Section 2A. The confusion due to the differing origins of the various state systems, and the resulting gaps, overlaps, and discrepancies between the geographical values of common sheet edges of adjacent systems added considerably to the difficulties of the revising units and caused much delay. Technical instructions on the problems involved were issued by S.H.A.E.F. Survey Directorate from time to time to guide the survey units and to ensure uniformity.

Some people felt that a monochrome edition, following the style of the original German map, was unsatisfactory. S.H.A.E.F. therefore authorized the responsible survey authorities with army groups to prepare their own colour overprints so as to clarify water, woods, roads, etc. When time allowed for the extra printing, this undoubtedly made a better map. To standardize results S.H.A.E.F. issued specifications, not only for the revision of detail but also for the preparation of the colour overprints.

To deal with the revision area allotted to him D. Survey 21 Army Group sub-allocated blocks of sheets to the Second British and First Canadian Armies and also set up an air survey group in Brussels by concentrating a number of

General Field Survey Sections under the control of No. 1 Air Survey Liaison Section. Photos were obtained from various sources including A.P.I.S. (21 Army Group) and C.I.U. (Medmenham). It was always a struggle to obtain photo-coverage of the right quality and of the areas required to enable the revision programme to proceed without interruption or delay.

Com. Z. sub-allocated sheets to 6th and 12th Army Groups who, in turn, allotted revision areas to the topographical units with the armies under command. Responsibility for a great part of the American area was assigned to the base mapping units and to the French Institut Géographique.

The standard German series did not extend over Bavaria. This was covered by a separate series at 1/25,000, the sheets of which were rather smaller than those of the main German series. There was, unfortunately, a large gap in Bavaria which had not been mapped at all on the 1/25,000 scale, though there was a 1/50,000 series which gave complete coverage. The task of compiling 1/25,000 maps to cover this gap was assigned to the American base mapping units, but work was delayed for nearly seven months because the air forces had not secured the necessary photographic coverage for Multiplex compilation. When, eventually, the photographs became available in the spring of 1945, the area had already been overrun. This failure to supply essential photography might quite easily have led to a dangerous tactical situation owing to the lack of proper maps.

The revision of the German 1/25,000 maps formed one of the principal tasks of allied survey units during the autumn and winter of 1944, and the early spring of 1945. The production of revised editions just managed to keep pace with the operations leading up to and including the Rhine crossing. Owing to the rapid movement of the allied armies east of the Rhine into the heart of Germany there was a reduced demand for 1/25,000 maps.

MISCELLANEOUS MAPPING

It would be confusing and unnecessary to tabulate all the diversity of mapping jobs that were undertaken day by day by all the various survey units which were serving overseas with the Allied Expeditionary Force. The following items are quoted as representing some of the principal tasks carried out:—

(a) *British Survey Units.*

S.H.A.E.F. From the moment they arrived at Suresnes (Paris) in October, 1944, 13 Map Reproduction Section and 9 General Field Survey Section were working full out and never had an idle moment. As previously described, their work was primarily concerned with the production of maps of all sorts required by *S.H.A.E.F.* staffs for planning, operations and intelligence, and other staff branches. This was a commitment of some magnitude.

Another major task was the preparation of administrative and zonal boundary maps of Germany to which reference has been made in a previous paragraph. As soon as the Allied Airborne Army began to base its operations on the Continent instead of in the United Kingdom, there was a constant requirement for the urgent printing of 1/25,000 and other maps.

S.H.A.E.F. Survey Directorate published regular and frequent progress reports and survey circulars dealing with standard map publication, revision and other subjects. Many of these were illustrated by

fully coloured index diagrams, and the preparation and printing of these at short notice was always most efficiently carried out.

When the Pas de Calais had been cleared of enemy forces, the V-weapon launching sites fell into allied hands. Amongst these were some of specially complex design and a survey of them was asked for. No. 9 General Field Survey Section carried out the ground surveys and then produced a series of fully detailed plans showing the workings both above and below ground.

21 Army Group Headquarters. The units which worked under the direct control of D. Survey 21 Army Group comprised four map reproduction sections, one field survey company and two (sometimes more) general field survey sections. As with any big headquarters, there was a continuous day-by-day demand for special maps and diagrams, overprints, and index diagrams to illustrate the reports and other documents prepared by the staffs concerned with planning, operations and intelligence, engineers and signals, artillery and air. Probably the biggest task of the map reproduction sections was the printing of medium and small scale maps. By agreed policy the War Office was responsible for sending over bulk stocks of these but the difficulties of supply at certain periods, and the need for insuring against the non-availability of stocks in critical emergency, made it necessary on many occasions to undertake local printing of bulk stocks. There were also urgent demands for stocks of 1/25,000 and other maps for planned airborne operations.

The revision of the German 1/25,000 maps formed one of the principal tasks for the drawing sections, and the reproduction in colour of the German 1/50,000 series of Holland provided a very popular map during the allied operations in that country.

It would be impossible to tabulate all the printing jobs undertaken by the reproduction sections. Averaging about seven or eight million colour impressions each month up to February, 1945, this number increased to over 13,000,000 in March, and continued at that rate till the close of the war. Most of this was on account of standard map bulk printing. Apart from this there were the intelligence maps and diagrams, town and port plans, road information maps, defence overprints, airfield detail maps, flak maps, flooding overprints, airfield location maps, canal and railway communication maps, and so on. The printing of trig lists and triangulation diagrams was a constantly recurring item and, whenever there was a spare machine, there was the never-ending task of printing "cancellation" markings on captured enemy map stocks so as to be able to print our own maps on the reverse and so save paper stocks.

The high output of the map reproduction sections in Brussels and Antwerp during the winter and spring of 1944-45 would not have been possible with the man-power and plant of the sections alone. Each unit added considerably to its resources by using civilian machinery and equipment, and by the employment of Belgian lithographic tradesmen and non-skilled workers. The two principal installations were 15 Map Reproduction Section in a large printing works in Brussels, and 14 Map Reproduction Section in a similar works in Antwerp.

British Second Army. Printing by the survey units with Second Army was limited to what could be put on their demy-size mobile presses. This included all the standard 1/25,000 series which were made up specially for printing on mobile presses in the field, but excluded most of the standard medium and small scale maps which were mostly of a size requiring a double-demy machine.

When the Second Army was pursuing the enemy rapidly through Belgium towards the German frontier D.D. Survey decided to make sure of being able to print his own stocks of maps of Germany to cover the probable initial operations across the frontier, in case there should be difficulties of supply from rear depots. He therefore made up, for monochrome printing, a number of sheets in demy size on the 1/250,000 and 1/100,000 scale by reproduction from the G.S.G.S. standard sheets. As events turned out these were not required.

A period of relatively static conditions on Second Army front which succeeded the pursuit through Belgium again brought demands for the usual variety of special maps and overprints which are incidental to the headquarters and formations of an army in the field, e.g., artillery fire plans, flood- and water-level maps, defence overprints, "Going" maps, etc.

All Second Army survey units took their share in the revision programme of the German 1/25,000 series, and a considerable amount of new large scale mapping was undertaken from air photographs in anticipation of important operations on the Maas and Rhine Rivers. Amongst these was a series of some 20 sheets at 1/12,500 scale along the R. Maas which was ready early in 1945 and, in conjunction with the Canadian survey units, a series at similar scale covering the River Rhine along the army front for use during the assault crossing.

The volume of printing varied from month to month. In September, 1944, a total of over 4,000,000 colour impressions passed through Second Army machines. The monthly average then fell to between two and three million until March, 1945, when it increased to nearly 5½ million.

(b) *First Canadian Army* (see also Chapter XIII, Section 1).

When enemy resistance stiffened in Holland, Canadian survey units were again occupied with 1/25,000 printing. The new series covering western Holland (GSGS 4427) which had been produced in eight colours was not suitable for economical printing in the field and, though it was a well drawn and extremely clear map, it contained many errors due to faulty interpretation. The Canadians, who were operationally concerned with this part of Holland, therefore revised a number of sheets, and in the process they reduced the number of printings from eight to four.

Although Antwerp was captured early on during this second phase, it could not be developed as a major supply port until the approaches up the Scheldt estuary had been made good. This involved the cleaning up of an area north of Antwerp, followed by the ejection of enemy forces from the islands of South Beveland and Walcheren. For these operations Canadian survey units prepared several special maps, mostly on a large scale, from air-photos. These included sheets at 1/10,000 of both islands, and five sheets at 1/5,000 covering the assault landing

area on Walcheren. There were also numerous defence overprints, fire-plan maps, and other special items. They also published town plans at 1/10,000 of many places in Holland which had not already been included in the War Office programme.

The 1/12,500 River Rhine series was another new large scale compilation from air-photos. First of all there were 12 sheets in the Arnhem-Zutphen area, and these were followed by several others covering the R. Rhine from Arnhem to Duisberg. Part of this was done to assist Second Army in their preparations for the Rhine crossing.

A Canadian modelling team became effective during October, 1944, and amongst their productions was a cross-section model of the Walcheren Island Dyke which was required by the Special Service force taking part in the assault.

With the possible need for occupying some of the Frisian Islands, the 1/25,000 maps were checked against recent photographs, and it was found that considerable alterations were necessary, especially with regard to the coastline detail. The sheets concerned were therefore recompiled by Multiplex methods and redrawn. Six new sheets on 1/12,500 scale of parts of the islands were also produced. Finally some beach-gradient determinations were made by measurements on air photographs.

Four sheets at 1/4,000 scale lying along the Maas River were produced in February, 1945, for a special operation undertaken by 4 Canadian Division.

Canadian Survey units published a series of nine sheets on 1/5,000 scale between Emmerich and Rees on the R. Rhine, and another four sheets along the Neder Rhine in the Arnhem area.

In common with the other allied survey units, the Canadian Survey Companies took their share in the revision of the 1/25,000 (GSGS 4414) series of Germany and the preparation of colour overprints for roads, woods, and water, where considered desirable.

From time to time the Canadian Air Survey Company was called upon to determine heights of banks and other objects and construct cross-sections, mainly in connection with river crossings and other such obstacles, in particular the crossings over the Seine and Rhine. The technique included the stereoscopic examination and measurement of vertical and oblique photographic cover, and ground checks which were taken subsequently showed that, where there was good stereoscopic oblique cover, the mean average error for all scales was just under two feet.

Experience indicated that the best conditions for heighting from obliques involved the use of simultaneous vertical and oblique photographic cover. The vertical photos should preferably have a scale of about 1/8,000, with full stereoscopic overlap. The lateral obliques should have a depression angle of 30 to 45 degrees, with full stereoscopic overlap, and be taken from a height not exceeding 2,000 feet.

From just over half a million colour impressions in October, 1944, the volume of monthly printing by Canadian units rose to 3,000,000 in March, which was the peak month. The heaviest single week saw 304,000 maps printed with a total of 1,045,000 colour impressions, giving an average of 37,000 impressions from each machine each day. Estimates

of production were usually based on a figure of 25,000 impressions from each machine each day and this rate was maintained throughout in spite of breakdowns and other difficulties.

(c) *U.S. Topographical Units.*

In accordance with the 1/25,000 revision programme for Germany initiated by S.H.A.E.F. Survey Directorate all U.S. topographical units, both at the base mapping plant and with the field armies, were extensively engaged on the revision of the sheets allocated to them, and the preparation of the colour overprints for roads, woods and water to make the map clearer to read. This work went on throughout the winter months and into the early spring of 1945.

As has been mentioned in Section 2A, a block of some 30 sheets of the new 1/50,000 map of Germany (GSGS 4507) was assigned to Com. Z., and the work of compilation and drawing was undertaken by 660 Topographical Battalion at the base mapping installation. Revised 1/25,000 sheets were used as basic material, six such sheets making up the area covered by one 1/50,000 sheet. The six sheets were fitted up to a grid and reduced photographically to 1/35,000. Blue line prints were then made on which the cartographic detail was fair-drawn for four-colour reproduction. The German symbols were converted to conform to the War Office specification, and the latest available photos were used for incorporating a final revision. As the area concerned fell within the operational zones of both the American and French armies, the marginal notes were bilingual.

To facilitate the reduction of the forts and other defended zones in the Metz area, where part of the U.S. Third Army was temporarily held up, topographical units produced in the first place 19 sheets of an uncontrolled photo-mosaic at a scale of approximately 1/25,000. They were made up from photos taken at 1/10,000 scale, and each sheet was gridded independently. This was followed by a series of large scale maps of the fortified group areas, and models of the forts themselves were also made on which the operational plans for their final capture were drawn up.

When 6th (U.S.) Army Group made contact with the southern flank of 12th (U.S.) Army Group and was fighting in the Vosges and Saar districts, the 1/25,000 map coverage of that area was incomplete. Part of it had been mapped by the French in accordance with their pre-war mapping programme along the frontier regions, and where these sheets had been available to the War Office, reproductions had been made and kodaline negatives distributed to all concerned. In some cases, however, 6th Army Group was able to make its own reproductions from newly obtained French material, and the great advantage of retaining the national sheet line system became manifest. Where a comparison with air-photos showed it to be necessary, revision of these GSGS 4411 sheets was carried out by American and French topographical units of 6th Army Group.

Although the War Office programme of town plan production was a big one, there were local demands for plans of many of the smaller towns, and these were produced by topographical units with armies and corps, many of them being in the form of annotated photo-mosaics.

Before "D"-day, S.H.A.E.F. Survey Directorate had produced a road map of Germany in nine sheets at 1/500,000 scale by reproduction from a road atlas. The result was not satisfactory and, when the allied armies were advancing towards the German frontier, there was a demand for a better road map on a scale larger than the above. In view of the heavy mapping and revision programmes already in hand, it was decided that the only feasible answer at the moment was to make use of the standard 1/250,000 map of Germany (GSGS 4346) and adapt it for use as a road map. There was no comprehensive system of road numbering in Germany as in France, so authority was given to the U.S. army groups to establish their own road-numbering system, and to make their own necessary adaptations of the 1/250,000 map in conformity with a specification drawn up by Com. Z., who allocated tasks to the army groups. Several sheets were published, but the result was not wholly satisfactory.

An arrangement was then made by Colonel Milwit with the Michelin Company for the production by them of a two-sheet road map of Germany at 1/M scale. This followed closely the general style of the well-known Michelin maps of France and proved to be a most useful map for road movement.

The next project was the initiation of a 1/200,000 road-map series of Germany by colour-separation from a German "Strassenkarte von Deutschland." The work was shared between the base mapping units and the army topographical battalions of 6th and 12th Army Groups. Work on this continued during the early months of 1945.

An immense number of special maps and overprints was produced by U.S. army and corps topographical units to meet the day-to-day operational requirements of their parent formations. This demand was specially large when operations were held up by major obstacles such as the Siegfried Line and the various river lines which were encountered. In the case of the former there were overprints on 1/25,000 maps showing in detail the formidable defences, and for the Rivers Roer and Rhine the staffs required maps to study and illustrate the flooding problems. Other maps were needed on which to draw up plans for bridging, traffic control, road and rail developments, and other purposes. Some of these requirements were met by the production of special mosaics and large scale photo-maps, but it was mostly a case of map compilation from air-photos.

Before the Rhine crossings, First U.S. Army undertook an intensive study of the river banks, and several sheets of the 1/12,500 Rhine River series were overprinted with appropriate engineer data. Many of the standard 1/25,000 sheets were overprinted with road and bridge information affecting the river crossings and subsequent exploitation.

For most of the standard map series gazetteers were published by the War Office in conjunction with the I.S.T.D. The War Office programme did not, however, include a gazetteer for the German 1/100,000 map (GSGS 4416). So the topographical engineer with 6th Army group initiated the production of one to cover a group of about 50 sheets affecting his own army group area. Both the 12th (U.S.) and 21 (British) Army Groups agreed to take their share in this work by extending the area of the gazetteer to the north, and the necessary material

was compiled. The 1/100,000 gazetteer had not been published, however, before the end of the war.

It is difficult to arrive at any firm figure for map production by U.S. topographical units within the theatre, but the following represents an approximate estimate of the number of map copies printed by the organizations shown between June, 1944, and May, 1945:—

660 Engineer Topographical Battalion (Base)	18,000,000
French I.G.N. (including civil firms)	28,000,000
12th Army Group topographical units	46,000,000
6th Army Group topographical units	11,000,000
	<hr/>
Total	103,000,000 copies
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At an average of three colours for each map this gives a total of over 300,000,000 colour impressions. In addition, close on 80,000,000 maps were received from the A.M.S., Washington, and nearly 50,000,000 from British sources during the period between "D"-day and "V.E."-day.

The final phase. (The Crossing of the Rhine to the final surrender)

OPERATIONAL BACKGROUND

The final operations, starting with the Rhine crossing, developed into a rapid pursuit of the enemy forces into the heart of Germany, concurrently with the Russian offensive from the east and the allied advance northwards from Italy, until the enemy finally surrendered early in May.

Apart from the activities necessary to maintain map supply for operations within Germany itself, there were two major operational possibilities that had to be provided for. In the first place there were strong rumours that the enemy would concentrate their best troops in the so-called "Austrian Redoubt." Secondly, there was a possibility that the Nazis might organize Norway as their last stronghold which would make it necessary for the Allies to mount offensive operations against them in Scandinavia. Both these possible courses of action involved a lot of complicated and urgent last-minute mapping preparations.

The need for affording protection to allied prisoners of war in their camps involved the possible use of airborne forces, and plans were made for them to be dropped over wide areas ahead of the advancing allied troops. This produced the usual urgent demands for large numbers of all sorts of maps to be specially printed. (*See also* Chapter XIV, Section 11.)

The early defeat of Germany was, however, certain, and all concerned had to anticipate the need for bulk map stocks for occupational purposes, including special maps dealing with administrative and zone boundaries.

With rapid movement following the Rhine crossing the need for 1/25,000 maps became temporarily less, so a policy was adopted of a limited printing of each sheet and rationed issues. Revision activity was switched to sheets covering the R. Elbe and other forward areas where the enemy might stage further defensive action.

In Second Army, overprints showing enemy defences were prepared, printed and issued for the Elbe crossings, the investment of Hamburg, and the clearing

of the Cuxhaven peninsula. Towards the end of April the slower tempo of operations and the need to map up a corps for operations in Schleswig-Holstein produced a bigger demand for 1/25,000 maps, especially for an area east of the Elbe and the approaches to Denmark.

The much-advertised "Austrian Redoubt" caused a great deal of extra mapping preparation. For planning purposes S.H.A.E.F. Survey Directorate produced some special maps of the "Redoubt" area to act as bases for the many intelligence and planning overprints which were required to accompany the staff studies. Hitherto Austria had been regarded as being within the operational mapping zone of A.F.H.Q., but it now seemed likely that forces under General Eisenhower's command might be the first to enter that country, and it was essential that maps should be available for all eventualities. By arrangement with A.F.H.Q. reproduction material for maps of Austria and northern Italy on various scales was flown over from Italy to S.H.A.E.F. and stocks were printed to meet the possible requirements of 6th and 12th Army Groups.

At the request of A.F.H.Q. Com. Z. undertook the preparation of some of the 1/25,000 sheets of Austria by Multiplex compilation, using air-photos flown over from A.F.H.Q.

Urgent consideration had now to be given to the revision of the 1/25,000 and 1/50,000 maps of Bavaria, for allied forces moving south into Austria.

To meet the threat of a German stand in Norway, S.H.A.E.F. drew up plans for an offensive into and through southern Scandinavia. This would have been mounted from the Continent, and involved considerable map preparation which had not hitherto been anticipated. Map stocks for the military occupation of Norway under "surrender" conditions had already been arranged for, and had been assembled at H.Q. Scottish Command, under whom the occupational operation would have been staged. A major offensive mounted from the Continent over large areas of Scandinavia was, however, a different matter. As soon as plans were known the Survey Directorate at the War Office undertook the immediate preparation of the maps concerned. Fortunately the final surrender in Germany took place soon after the work had been started.

Map printing overseas continued at a high rate right through to the close of hostilities. At S.H.A.E.F., 13 Map Reproduction Section, during April alone, completed 114 jobs involving the printing of over 635,000 colour impressions, a heavy task for a small unit possessing only two machines. Com. Z. and units with the British and U.S. army groups likewise had their machines running at full pressure during this final phase, dealing with the current requirements of operations, and preparing for the occupation.

SECTION 3. TRIANGULATION AND FIELD SURVEYS

(A) PREPARATORY WORK DURING THE PLANNING PERIOD

Strategical Background

Reference has already been made in Chapter II (Section 3), to the fact that two separate and discordant triangulation systems were concurrently existing in France; an old one which was started in 1792 and a new one which was begun in 1870. This new system extended over certain parts of eastern France, with special emphasis on the frontier districts opposite Belgium, Luxembourg, Germany and Italy. It was only for a very limited area lying roughly to the

north-east of Paris, along the frontier district between Luxembourg and the sea, that the War Office held French co-ordinate lists based on the new triangulation.

When considering survey preparations for a return to the Continent, it was vital to have early information about the probable areas in which an allied invasion force might be required to operate, in order that the long and laborious work of preparing trig lists could be started without delay.

After the allied landings in North Africa in 1942, the whole of France was effectively occupied by German forces and, even though priority attention would have to be given to the selected invasion area and the most probable axes of subsequent operations, it was clear that it would also be necessary to provide for operations which might have to be undertaken anywhere in France to defeat the German armies.

As soon as the planning staff organized by G.H.Q. Home Forces in 1942 under the direction of the Chiefs of Staff, had recommended that the Normandy coast, somewhere between the Cherbourg peninsula and the mouth of the R. Seine, appeared to be the most favourable site for an assault operation, the Survey Directorate at G.H.Q. Home Forces immediately began an investigation into the triangulation situation in that area. The strategical picture at that early date was that allied forces would land on the Normandy coast, establish a bridgehead while building up their strength and resources, and break out from the bridgehead capturing a port or ports such as Cherbourg, Brest, Nantes or Havre. After defeating the German forces arrayed against them they would drive them north-eastwards through Belgium and north-eastern France back into Germany, thus liberating in the process further ports for facilitating supply.

Triangulation data in north-western France

To the west of an approximate line Boulogne-Paris the only available triangulation was the old one established by the *Ingénieurs Géographes*. For this system the War Office held lists of trig points whose positions were quoted in geographical co-ordinates (latitudes and longitudes) to the nearest centesimal second only. Thus a doubt of half a second either way, owing to their having been rounded off to the nearest second, might give a total displacement from the true position of from six to ten metres, which might be a cause of much embarrassment to a field surveyor trying to resect his position from such points. It was more than probable also that many of the list values might be incorrect owing to the destruction of the original trig points, such as church spires, which might have been rebuilt away from their original positions. As there was no opportunity of clearing up these points of doubt with the French survey authorities at that stage, there was no alternative other than to accept the list values as they stood, leave it to the field survey units to check up the work on the ground and, if possible, to obtain more modern data on their arrival in France. The geographical values were therefore converted to rectangular co-ordinates on the appropriate grid systems which it was known the French had adopted for their own maps, and which it was decided to adopt also for use on British military maps.

Grid Zones in France and Belgium (see Diagram 8)

It will be remembered that, when preparing maps and trig lists for the use of the B.E.F. in France and Belgium in 1939, the War Office had agreed to use

the Lambert Nord de Guerre grid. The French had adopted this for war purposes to cover a zone extending over north-eastern France and Belgium into Germany, from a line in the west running north and south roughly through Havre and Le Mans, and whose southern limit was a line running approximately east and west through Orleans. When considering the preparation of maps for further operations in this area it was decided to retain this Nord de Guerre grid zone, which would be extended right into and through Germany. For the rest of France it was decided to use the Lambert grid zones which the French had adopted for their national maps of France. This divided France into three zones known as Lambert Zone I (in the north), Zone II (in the middle), and Zone III (in the south). Without going into complicated technical details it should be realized that, owing to the fact that a map portrays on a flat piece of paper the topographical features which occur on the surface of a spherical earth, it is not possible, except over very small areas, to portray such detail without some appreciable distortion of one sort or another. In order to reduce this distortion to acceptable limits, dependent on the purpose for which the map is required, various sorts of map projections are used by map makers. For military purposes, especially where long-range artillery requirements demand that bearing and range from gun to target shall be determined with as little error as possible from a combination of map measurement and ground surveys, the Lambert projection is suitable. When using such a projection it is possible to extend the grid zone as far as is desired east and west without introducing distortion. There is, however, a limit to the extension to north and south that is possible without exceeding the allowable error of distortion. With the probability of operating over long distances eastwards from the invasion area through Belgium into Germany, the Lambert projection was therefore especially suitable. The limits imposed on the extensions to north and south made it necessary to divide France into the three zones referred to above. The general arrangement of these and the Nord de Guerre zone is illustrated in Diagram 8.

One unfortunate feature of the accepted arrangement of grid zones will be apparent. There was a change of grid between Caen and Havre along the junction between Zone I and the Nord de Guerre zone. This line of junction passed through what seemed likely to be a battle area, and caused complications in the gridding of maps on all scales and also, of course, on the preparation of trig lists. There were other junctions which looked as though they might well fall within operational areas, namely those between Zone I and Zone II, where fighting for the clearance of Brittany might take place, and that between Zone II and the Nord de Guerre zone, which lay on a possible line of advance for allied forces moving towards Germany through eastern France.

The acceptance of these grid zones directly influenced the following:—

The gridding of maps which either existed or would be prepared for the operations.

The preparation of trig lists, so that the co-ordinates of trig points would be given in terms of the appropriate grid which would be found on the maps. This was of special importance with reference to large scale maps which would be used by the artillery.

Preparation of trig lists

If the values of the French trig points had all been based on one common triangulation, the conversion of their values from geographical to rectangular

co-ordinates appropriate to each grid zone would have been a comparatively simple matter. As explained above, however, the triangulation situation in France was very confused, being a patchwork of new and old, each based on a different figure of the earth, with different values for their common bases, different azimuths (or bearings) for their basic sides, and different values for their fundamental common "origin" on which the latitudes and longitudes were based.

Recognizing the need for some attempt at consistency, the French had taken their new triangulation and adjusted it to fit the basic fundamentals of the old. In addition, they made further local adjustments on a 1/50,000 map sheet basis so as to make the new values agree with previously published lists based on the old triangulation. This resulted in "cassures," or discrepancies in position, for points lying in the vicinity of the sheet edges, a fact which later on caused a considerable amount of anxiety and annoyance to allied field surveyors when they were working in those areas.

With all this variety and uncertainty about the available data the preparation of trig lists and other survey data for "Overlord" offered many problems. There follows a brief summary of the trig-list situation for western Europe as it existed at the conclusion of the planning period in May, 1944, immediately before the invasion. The work of preparation was most ably controlled by Lieutenant-Colonel W. E. Browne of the Survey Directorate at S.H.A.E.F., and was carried out by a variety of organizations including the S.H.A.E.F. Survey Directorate itself, British and American survey units, the War Office, and the Ordnance Survey.

(a) *North-eastern France and Belgium.* Printed lists of trig points, giving their rectangular co-ordinates on the Nord de Guerre grid, were published on a 1/50,000 map-sheet basis. The values were mostly based on the new French and the Belgian triangulations, but a considerable amount of adjustment and deliberate distortion was introduced. Much of this work had been done by the B.E.F. Survey Directorate in 1939-40, and has already been referred to in Chapter II. Briefly, the procedures which had been involved in dealing with the original data were as follows:—

- (i) The computation of an "undistorted" system in Belgium and Holland as an extension from the French triangulation, using the original triangulation records.
- (ii) Adjustment of this "undistorted" system, and the minor triangulation system in eastern Belgium, so as to accord with the existing Nord de Guerre trig values in western Germany which had been prepared by the French, and also with the Dutch triangulation.
- (iii) Correction of the minor triangulation in western Belgium to accord with the French homogeneous Nord de Guerre values which became available, and also with the Dutch and German triangulations.
- (iv) Correction of the minor triangulation in southern Holland to accord with the Nord de Guerre values in Belgium and western Germany.

The object of all this adjustment and distortion was to smooth out the breaks or "cassures" which would otherwise have existed at the junctions between the various national systems. Such breaks would

have been very disconcerting and awkward if operations developed in such areas. A full description of the work undertaken is given in a pamphlet entitled "Triangulation situation in Northern France, Belgium, Holland, and Western Germany" which was compiled by Lieutenant-Colonel Browne and published by the Survey Directorate, S.H.A.E.F., in 1944.

In the trig lists the points were classified in the following categories:—

- (i) Primary points (French and Belgian classification).
- (ii) Secondary points (French and Belgian classification).
- (iii) Minor points (French and Belgian classification).
- (iv) Points in the *old* French triangulation, or points fixed during the 1914–18 war, of which both the existence and accuracy were doubtful.
- (v) Points fixed by survey units in 1939–40 which were generally of a high degree of accuracy.
- (vi) Other points fixed by survey units in 1939–40 to a lesser degree of accuracy and certainty.

All the points contained in these lists, *except where a cautionary note was inserted*, could probably be used as they stood for R.A. survey fixations or for the establishment of local bearings. It was estimated that bearings between any two such points might be expected to be correct to within about one minute of arc. When observing check rays for bearing, all users were warned that distant points should always be used.

- (b) *Holland.* Co-ordinates on the Nord de Guerre grid were compiled in lists on a 1/25,000 map sheet basis. The values were based on the Dutch records and were, as above described, subjected to certain distortions so as to fit in with the distorted Nord de Guerre co-ordinates for eastern Belgium and the French Nord de Guerre values for western Germany.
- (c) *Western Germany.* The German provinces bordering the Rhine in the Saar region were covered by five booklets which had been published by the French. These booklets were reproduced for issue, the lists having been compiled on a German 1/25,000 map sheet basis. Co-ordinates had been computed on the Nord de Guerre grid as a so-called extension from the French triangulation in the Saar. This was not a true extension from the French triangulation. The German geographical co-ordinates were converted to rectangulars on the Nord de Guerre grid after applying a blanket correction for origin based on a mean comparison of geographical values for common points in the region of the Saar. This simple correction was not a proper one, as the German geographicals were based on the Bessel-Kruger figure of the earth, while the French values were based on the Carte de France figure, and the Nord de Guerre tables were drawn up on the du Plessis spheroid. A further complication arose owing to an azimuth error in the French triangulation. All this resulted in a lack of orthomorphism in the Nord de Guerre values of the German points. The resulting co-ordinates were known as the German "Nord de Guerre," and were the best that could be produced under the circumstances. The above facts should be borne in mind in the event of any future preparation of new trig lists for western

Europe. It might also be considered preferable to adopt the German Gauss-Kruger grid for all mapping and survey purposes in that area. The selection of the most suitable grid system for military purposes in Europe certainly requires careful consideration. S.H.A.E.F. Survey Directorate computed extensions northwards from the Rhine Provinces to Denmark, and also to the east.

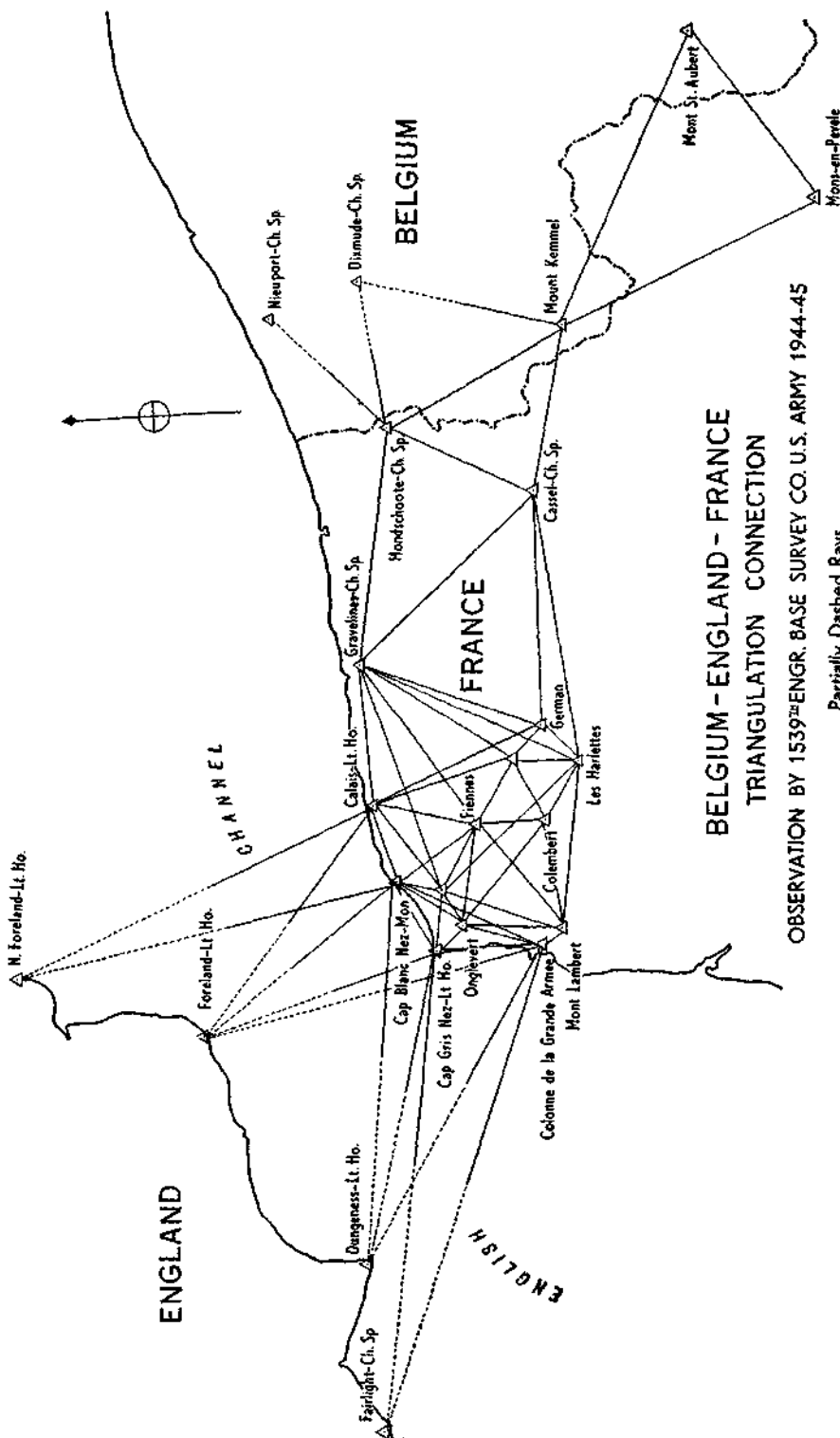
- (d) *North-western France.* The unsatisfactory situation existing in north-western France regarding trig co-ordinates has been described in this Section under the heading "Triangulation data in north-western France." As it seemed unlikely that resection in the field from these trig-list values would give satisfactory results they were issued only to R.E. survey directorates and units, with instructions on how best to utilize them for survey work in the field. For those map sheets which lay astride, or just on either side of, a grid junction, lists were prepared and issued on both grid systems concerned. In addition, lists of transformation factors were published so that units could, if desired, convert the values from one grid system to the other.
- (e) *Central and southern France.* Although priority was given to the completion of trig lists covering northern France, where the initial operations would take place, a similar programme was put in hand for the rest of the country. With the probability also that allied forces from the Mediterranean Theatre would eventually make an assault landing in the south of France arrangements were made with A.F.H.Q. for them to take on a share of the trig-list preparation in the south. Thus, in course of time the whole of France was covered with these lists.

Cross-Channel triangulation connection

When German heavy guns were mounted on the French coast opposite Dover in 1940, there were demands for an accurate connection between the British and French survey systems, so that a relation could be established between points on either side of the Channel. From points in the British triangulation system along the Kent coast, observations were therefore made to prominent points on the French coast such as lighthouses and church spires which were known to form part of the French system. Trig points on the English coast were then converted to the French Nord de Guerre grid system. Later, in 1944, when it was known that launching sites for V-weapon attacks on Great Britain were being developed in the Pas de Calais, the area included within the original cross-Channel connection scheme was extended westwards along the English coast, and also along the French coast towards Le Havre. Details of this work were given in Lieutenant-Colonel Browne's "Report on the Cross-Channel Connection" together with the various addenda thereto. It is of interest to note here that in 1944-45, when the German forces had been driven out of the Pas de Calais, the connection was strengthened by observing back from the French coast on to the English triangulation stations (*see* Diagram 9).

Connection between Continental triangulations and that of Great Britain

With the development of radar, and an increase in its range of action, it was necessary to establish as accurate a relation as possible between the British and Continental survey networks, extending right into the heart of Germany.



BELGIUM - ENGLAND - FRANCE
 TRIANGULATION CONNECTION
 OBSERVATION BY 153RD ENGR. BASE SURVEY CO. U.S. ARMY 1944-45

Partially Dashed Rays
 Indicate Observations from Solid End Only

Making use of the original cross-Channel connection observed in 1862, and working through the first-order French and Belgian triangulations, computations were carried out to connect the British and German systems. All calculations were referred to the "Airy" spheroid, the values for which had been used for the calculations of the British triangulation framework. Advantage was taken of the fact that a common point existed at the junction of the Dutch, Belgian and German systems. The results of this early computation were, of course, prejudiced by the uncertainty of the connections between the national systems along their frontiers but, as will be seen later, this was subsequently remedied by a reobservation of the geodetic connections concerned. The results of the early work are given in a paper entitled "Geodetic connection of the triangulations of France, Belgium, Holland and Germany to the triangulation of Great Britain in terms of the Airy Figure of the Earth," by Lieutenant-Colonel W. E. Browne, R.E.

Training of survey units for field survey work

Although most of the field survey units which took part in "Overlord" had been in existence for some time, it was generally felt that there had not been sufficient opportunity for training their personnel in field survey operations. It was undoubtedly a fact that they had to be employed during most of their time in the United Kingdom on other forms of work. This was especially the case during the few months preceding "D"-day, during which time all available personnel were employed full time on the preparation from air photographs of the 1/25,000 maps of the invasion areas. This was essential work of great urgency and, as events proved later on, was an excellent training for similar work which they had to perform subsequent to the pursuit of the German armies through Belgium. It was always expected, however, that the topographical sections, after arrival in France, would be required to carry out rapid programmes of check surveys, new triangulation to provide control for the R.A. Survey Regiments and other forms of topographical field survey. On the more important training exercises for all arms which were periodically staged in the Home Commands, opportunity had been taken to introduce a survey picture simulating the conditions which would probably be found in France, and the R.A. and R.E. survey units had had these limited opportunities of working in co-operation with each other. But time for more intensive training of this nature was not available.

In the invasion area, where the trig-list values were of such doubtful accuracy, it seemed likely that a new triangulation would have to be observed, most probably on a local area basis, and on a local grid. Methods were therefore devised whereby such a local scheme could be adjusted quickly and readily to the standard theatre grid. Details of one such method are contained in a pamphlet entitled "Triangulation in Areas where existing Trig Lists are of doubtful Value," by Lieutenant-Colonel W. E. Browne, which was issued in December, 1942, and reprinted in October, 1943, by the Survey Directorate at H.Q. 21 Army Group.

Operational Policy Memoranda

To ensure a measure of standardization and co-operation between the allied forces, S.H.A.E.F. issued a series of "Operation Policy Memoranda" on a variety of subjects. One of these, No. 28 (*see Appendix I*), dealt with the

conduct of "Artillery and Engineer Surveys." Although not laying down any standardization regarding technical methods of surveying, it did emphasize the necessity for standardization in such things as the preparation of new trig lists in the field, the numbering and marking of trig points and grid nomenclature.

(B) FIELD SURVEYS OVERSEAS

Within the Normandy Bridgehead (June–August, 1944)

FIELD SURVEYS

Bearing in mind the plan for the development of operations subsequent to a successful assault landing, D.D. Survey Second Army (Colonel A. W. Heap), who was controlling the initial survey operations within the bridgehead, had made a careful advanced study of local topographical conditions from available maps and other material, and had worked out various alternative projects for dealing with the supply of a control framework.

On 12th June, immediately after landing, 519 and 521 Field Survey Companies started work in the Bayeux–R. Orne sector. Their primary task was to check the existing triangulation as given in the S.H.A.E.F. trig lists, and to provide new control where necessary as a firm base for further surveys. Their second task was to provide co-ordinates and bearings where required by the artillery in forward areas, including the fixation of points in enemy territory, carrying these forward day by day as the tactical situation allowed.

From a common base, centrally situated, whose ends were resected from listed up-stations, 519 Company worked to the west in 30 Corps area, and 521 Company to the east in 1 Corps area, their trig schemes being so planned as to incorporate as many as possible of the listed trig points in their observations. Both units concentrated their topographical sections in the actual battle-zone, working in close co-operation with the R.A. Survey Regiments of 30 and 1 Corps respectively, and allotted the coastal strip to the General Field Survey Sections under their command.

During the available training period in the United Kingdom, Browne's method of trig adjustment, referred to in Section 3A, had been further developed by Lieutenant G. L. Thomas, R.E., who evolved an easily worked least-square method which, in calculating the adjustment, made use of all the listed trig points included in the observations. The method was particularly useful for checking listed co-ordinates, as it detected unreliable points at an early stage in the computation. This method was used by the Second Army units in the Normandy operations, and was fully described in a pamphlet printed and issued by Second Army in June, 1944.

It was not long, however, before captured German trig lists became available. These gave co-ordinate values of French trig points to the decimal point of a metre (differing, however, from the S.H.A.E.F. values by about 70 metres), and also of new German points, many of which had been left, marked and beaconsed, and had already been used by our survey units. Comparison with the Second Army observations indicated that the Germans had indeed already completed the required check of the French triangulation in the coastal belt, and that their work was good. By empirical methods correction curves were then rapidly calculated to convert German values to S.H.A.E.F. values, eliminating the "sliding" discrepancy of approximately 70 metres, and the

Second Army observations were recomputed, using the "Thomas" adjustment, to the converted German values, the intention being that any further captured German co-ordinates could be accepted without further question. Unfortunately, the captured German lists covered only a very small area; nevertheless, it is of interest to note that the empirical adjustment curves agreed to within about $\frac{1}{2}$ -metre with the S.H.A.E.F. correction graphs subsequently published which were based on the Driencourt formula referred to later.

During July the trig work consisted of probing forward to the south and south-east as far as the slow movement of operations allowed, and also westwards to conform to changes in the boundary between Second Army and First U.S. Army. Work in the Caen area was handed over to the First Canadian Army towards the end of July.

It is significant to note the comments of D.D. Survey Second Army during this early period. He observed that the lack of sufficient previous training in field survey, already referred to, was showing its effect on the trig and topographical work being undertaken. Much time was lost by the consequent amount of detail work thrown on the Survey Directorate, and the need to re-observe a good deal of the work. The slow progress of operations during July afforded an opportunity to use the work of the units as training.

The need for close liaison with infantry brigades and battalions was essential as orders had been issued by Second Army that no army troops units should work in the forward areas without permission of the relevant formations.

The Falaise battle and the break-out of the British, Canadian and American armies from the bridgehead took place in August. The U.S. First Army cleared up the Cherbourg peninsula, and U.S. Third Army, having broken out to the south, turned east and, forming the right flank of the allied advance, began the swift pursuit over the Seine and beyond.

519 and 521 Field Survey Companies carried forward a fully observed triangulation towards Falaise, ultimately tying their work together on common points. 521 Company also tied in on common points with First Canadian Army to the east, and 519 Company with First U.S. Army to the west. Canadian topographical sections in the Caen area extended their work south-eastwards towards Falaise, maintaining close co-operation with the Canadian Survey Regiments and, as the latter had suffered serious casualties, the topographical section survey was carried into A.G.R.A. and divisional artillery areas.

Corps topographical units of First U.S. Army at the western end of the bridgehead were primarily engaged in checking the published trig lists and establishing control for artillery uses, working in close contact with the field observation battalions. The Army Topographical Battalion was employed running a traverse control net for tying together the data established by the Corps topographical units. The general area covered by them was in the vicinity of Periers, St. Lo, and Vire.

Towards the end of August the break-out occurred, the pursuit was on and, for the time being, field surveys to provide control for artillery requirements were broken off, owing to the speed of movement.

CROSS-CHANNEL CONNECTION BY OBSERVATION BALLOON

An attempt was made during August to establish a triangulation connection between Normandy and the south coast of England by observing from both

sides on to balloons towed along mid-Channel. This was unsuccessful owing to poor visibility, and the attempt was not repeated.

NEW EDITIONS OF S.H.A.E.F. TRIG LISTS

The trig-list situation during the weeks following "D"-day became somewhat confusing. Mention has been made of the issue of Second Army trig lists after the capture of some German documents. Through Intelligence sources S.H.A.E.F. then obtained a number of modern trig lists covering parts of northern France. These were evidently coming through underground sources from the Service Géographique in Paris. The lists gave values in the form of rectangular co-ordinates to one decimal place of a metre. There was no indication of their reliability but, as the values were given so precisely, it was assumed that they represented an advance on anything already in our possession. As the co-ordinates were given in terms of the new triangulation, it was necessary to convert them to the theatre grid which was based on the old system. Revised lists covering the battle area were prepared by S.H.A.E.F. and issued to all concerned.

As soon as it was known that the Germans were using Lambert Zone I co-ordinates based on the new triangulation, S.H.A.E.F. issued a Technical Instruction with graph giving a quick and convenient means of converting them to the theatre grid. The graph was based on a theoretical correction derived from the Driencourt formula. Similar graphs covering the Zone II and Nord de Guerre areas were also prepared. Hitherto there had been no evidence to show that the new triangulation had penetrated into that part of Normandy.

Two further German booklets which were captured gave a lot of important information. These described German survey activities in France from the date of the occupation in 1940 until May, 1943. A S.H.A.E.F. Technical Instruction was published describing the work undertaken. It appeared that extensions of the new triangulation system had indeed been carried out both by the French and the Germans. This work, as far as was then known, consisted in the main of first-order extensions to the west along the parallel of Paris to Brest, along the Bourges parallel connecting Dijon and Nevers, and along the Toulouse parallel in the south. There was also a considerable amount of second-order work filling the gaps between the main chains.

A few days later some further captured material threw considerably more light on the situation. It was then proved that the French and Germans between them had completed all the originally projected "first-order" nets in France with one or two exceptions. What was of special operational interest, however, was the evidence that the Germans had connected, by a second-order triangulation, the new first-order triangulation at Amiens to the new western extension of the Paris parallel (*see above*), making a junction at Mont St. Michel. This new second-order work traversed the whole length of the Normandy coast, and had been surveyed by the Germans in 1942. It was established that the recently captured German booklets, which were dated May, 1943, contained definite values based on this new work, and were therefore the most accurate values for the trig points that we were likely to obtain. A new S.H.A.E.F. Technical Instruction was therefore published giving all this further information, accompanied by a graph which gave the subsidiary corrections to be applied to the May, 1943, German lists to reduce them to the same terms as the theatre grid, after conversion through the

Driencourt formula. Revised trig lists embodying the latest values were also published. In this connection it should be explained that, when new trig lists were published by S.H.A.E.F. in the field, they were not issued in printed form. Having prepared the original lists in manuscript, bromide paper negatives were made, and these were distributed to the army groups so that they could make their own plates for reproduction, and print their own stocks of trig lists as required.

All these constantly recurring changes in the trig-list values consequent on the capture of enemy documents were no doubt very tiresome to survey units in the field, but it is inevitable under conditions where low-grade information only is available at the beginning of operations, and where data of greater accuracy are acquired as operations proceed.

When the break-out from the Normandy bridgehead took place in August, and the speed of pursuit put a temporary end to the need for control surveys, the worries incidental to uncertain trig-list values in Normandy came to an end. The rapid move of the allied forces into north-eastern France and Belgium soon took most of them into an area which was covered by the more reliable trig lists which had been published in 1940 by the G.H.Q. Survey Directorate, B.E.F.

Normandy to the Rhine (August, 1944–February, 1945)

FIELD SURVEYS

The First Canadian Army, after crossing the Seine, formed the left wing of the allied advance, and had the task of cleaning up the Pas de Calais, including the V-bomb launching sites, and liberating the Channel ports. During the middle of September, 2 Canadian Field Survey Company deployed near St. Omer in country which was very suitable for triangulation and where several German survey towers proved most useful. Work started near St. Omer and extended west towards Boulogne and east towards Poperinghe, covering a frontage of about 40 miles. The list values for the primary points in this area were found to be reliable. Secondary and tertiary points did not check in so well. As a result of their observations the Canadians issued new values which were used for the battles round Boulogne and Calais and subsequently at Dunkirk. During this period it was found convenient to attach two topographical sections from 2 Canadian Field Survey Company to the artillery survey regiments operating in the area.

In the latter half of September, the Canadian Company moved to the Ghent area, which was not suitable for triangulation. Topographical sections were therefore deployed to check the trig-list values by traversing between Bruges and Ghent, and between Ghent and St. Nicholas, and this was later extended northwards. In all, about 180 miles of traverse was completed, the trig-list values being found to check in well.

Apart from these check traverses, the following special tasks were undertaken by the Canadians:—

Traverse loops were extended into Holland between Phillipine and the mouth of the Scheldt, with bearing pickets established at frequent intervals.

A survey for 107 A.A. Brigade was undertaken in the Dunkirk area, where the Germans were still holding out. This consisted of a traverse loop of about 50 miles linking up trig points, with spurs running into the gun areas.

A survey for a heavy regiment near Phillipine.

The quick moves of British Second Army at the end of August and during September put a temporary stop to control surveys in the field. Even the R.A. Survey Regiments were outpaced, and by the end of September there had been no need or opportunity to resume this type of work. The narrow corridor in Holland running up to Arnhem gave insufficient space for any useful R.E. triangulation work for artillery control purposes. In fact, there was really no need for it, as survey regiments found that the published trig-list points were generally reliable, and they could base their local surveys on them with no difficulty.

A special task was, however, carried out at Bourg Leopold, which was the Aldershot of the Belgian Army. There was a proposal to use the artillery ranges there for training purposes, and a survey was required to check the existing trig points within the range area and establish new ones.

During October several field survey tasks were undertaken by Second Army, including the provision of control for the fixing of sound-ranging bases, for connecting the survey networks of survey regiments, and for the fixation of sites for the chain of radar stations which was rapidly being set up over western Europe as the Allies moved east.

The Canadian Company had several moves during October. About half the unit was employed on the check of trig-list points, the remainder being used either in direct support of artillery survey regiments in an artillery survey role because of the lack of sufficient artillery survey personnel, or on other special tasks. The work in the Dunkirk area was completed during early October. Radar surveys were carried out in the Canadian area under control from D. Survey 21 Army Group.

American topographical units were similarly occupied in checking their listed points, surveying radar sites, and extending control in conjunction with their artillery observation battalions.

Bad weather conditions and increased German resistance slowed down progress during November and December and, during this latter month, the strong enemy offensive was launched in the Ardennes. Then in January came the resumption of eastward movement all along the front, cleaning up the whole area west of the Rhine, and leading up to the assault crossing over that last great obstacle into the heart of the Reich. During all these operations survey units with all the armies were frequently called on to provide control for the strong artillery support which was given continuously. Most of this work was done by resection and intersection using the trig-list co-ordinates.

TRIG-LIST SITUATION

Germany. The rapid pursuit of the German forces shifted the interest and activities of computing experts eastwards so that trig values would be available for operations into the very heart of Germany. Extensions to the existing trig lists covering the Rhine provinces had been added to the north and east. Further extensions were now in hand to cover Germany as far east as the meridian of $15^{\circ} 20'$ (E. of Greenwich), and southwards to the Austrian frontier. Part of this computing work was taken over by the United States.

The triangulation situation in Germany as a whole was complicated by the fact that surveys and mapping had originally been organized and carried out on a state basis, each with its own "origin" and basic fundamentals. During the period between the two wars the Germans themselves had started to unify these separate surveys on the basis of the Prussian (Einheit) system, but it was

still incomplete when the war started, and the result, from a military survey point of view, was complicated and confusing. For military purposes it was necessary that trig values in Germany should be converted to the allied grid system. This meant, in effect, the following action:—

The co-ordinate values for each separate state had first to be converted to the Prussian system.

The triangulation of southern Germany on this Prussian system was then distorted so as to fit on to the surrounding systems of France, Switzerland, Austria, Bohemia, and the French system of Prussian points in the Rhine provinces and in northern and central Germany.

All values had then to be converted to the allied grid system.

The conversion from state values to the Prussian system was effected by means of a blanket correction. The distortion to effect a smooth fit on to the adjoining systems was done by means of a so-called "grand graph" prepared by S.H.A.E.F. Survey Directorate, and the conversion to the allied grid system was done through the published tables. Nearly all this work was centrally controlled by S.H.A.E.F. under the guidance of Lieutenant-Colonel W. E. Browne, who contributed much valuable work in connection with the geodesy of western Europe during the planning and operational stages of the campaign.

There were, unfortunately, some areas in south-western Germany in the states of Hesse, Baden and Wurttemberg for which little triangulation data were available, and all formations were notified of the importance of searching for the missing data amongst captured enemy records. In anticipation of acquiring this, tables were issued by S.H.A.E.F. to army groups, and to the U.S. Communications Zone (Com. Z.), by which transformations to the Nord de Guerre grid of German co-ordinates on their Gauss-Kruger projection could be effected by survey directorates and units in the field.

In a later paragraph the activities of the "T" (target) Force parties for acquiring captured survey records are discussed. Amongst the material obtained was some further information about Baden and Wurttemberg. As soon as this was available, the work of converting the points to the allied grid was put in hand and trig lists were issued. But even by the end of January, 1945, the available trig data for southern Germany were still meagre, and consisted only of the following:—

- | | |
|--------------|---|
| Baden. | About 190 points (primary only). |
| Wurttemberg. | About 550 points (primary and secondary). |
| Bavaria. | About 115 points (primary only). |

This gave an average density of two trig points in Baden, and four in Wurttemberg, to a 1/25,000 map sheet, but in Bavaria there was only one point to about every five sheets.

For Bohemia trig lists were prepared from Austrian triangulation data and included primary points only. The Austrian values were adjusted through a graph to make them fit the German Nord de Guerre in the north and the Austrian Nord de Guerre in the south.

France. After the occupation of Paris, co-operation with the Service Géographique enabled a close investigation to be made into the French triangulation situation which had offered so many complications to date. Although many doubtful points were cleared up, it was obvious that there still remained a good deal of confusion regarding the various existing systems

of divergent co-ordinates, and this persisted throughout the entire period of operations. It seems evident that a great deal remains to be done in clearing up the geodetic situation and putting it on a sound footing, and no doubt this fact will be recognized by those responsible for post-war programmes of collecting and tabulating triangulation data of the Continent.

Amongst the new French material obtained were a number of trig lists covering the Rhine frontier region between France and Germany. Photostat copies were sent to 12th U.S. Army Group for their use. Copies of secret pamphlets containing co-ordinates of points along the Maginot Line were also made available by the French who gave whole-hearted co-operation and assistance in supplying this sort of data, as they did in map production and other forms of survey activities.

Hitherto no trig lists of Luxembourg had been published owing to the difficulty of relating the Luxembourg survey points with the French Nord de Guerre system. French trig lists of Luxembourg were now obtained and issued, and an examination of common points indicated that values were in sympathy to within two or three metres.

SURVEYS IN CONNECTION WITH THE DETECTION OF V-2 LAUNCHING SITES

The Germans fully realized the importance to the Allies of the port of Antwerp. When, therefore, after being driven from their V-weapon sites in the Pas de Calais, they organized a new rocket campaign from sites further east, the Antwerp area became one of their principal targets in the battle-zone. It was an urgent necessity to locate the new launching sites, and this involved the installation of groups of microphone detection stations. The need for an accurate survey of these positions did not at first seem to be appreciated by those responsible for controlling the detection devices, and it was fortunate that 2 Canadian Field Survey Company was in the vicinity at the time. Arrangements were made for this unit to carry out the survey work while awaiting the arrival of the R.A. Survey Regiment which was to install the microphone posts. At first there were 44 microphone positions in four groups. This number was increased later. For the initial lay-out the points were located by map spotting on 1/25,000 maps. All these points were then connected together by closed traverses which were tied in to the local trig framework. Within each group the points had to be sited 10,000 metres apart (± 3 metres), and altitudes were required to an accuracy of ± 1 metre. Having surveyed the positions of the map-spotted points, sketches were made covering an area of 100 metres radius surrounding each point. From these sketches final positions for each microphone could be determined whereby they would all be located at the required distance apart without clashing with a house or other obstruction. Having determined these final positions, their co-ordinates were fixed from the points already surveyed by single-leg traverses.

SURVEY "T" (TARGET) FORCE ACTIVITIES

The acquisition of captured enemy survey data and material, whether in the form of maps, trig lists, or other category, formed a vital part of survey operations. This was especially so when entering the enemy's homeland, where all his main depots and records were located.

Under centralized direction S.H.A.E.F. and the higher field formations organized special parties composed of Intelligence and technical representatives,

whose duty it was to search for, examine, and evaluate all captured documents and other material.

Survey Directorates at S.H.A.E.F. and with army groups arranged for representation with these parties, and their work began in France soon after landing. In this work it was necessary to maintain the closest possible liaison with the Intelligence branches concerned. Mention should be made here of a specialist investigation party of American personnel which was sent over by the War Department, specially trained in geodetic research. On arrival in France they came under the control of the Chief Engineer of the U.S. Communications Zone (Com. Z.). Their work was co-ordinated by D. Survey (S.H.A.E.F.) so as to fit in with that being undertaken by S.H.A.E.F. itself and by the army groups. The party, which was equipped with microfilming equipment, was commanded by Major Hough, who applied to the task remarkable energy and technical skill. During November detachments from his group examined potential sources of survey and mapping data in Paris, Aachen, Brussels, Liège, and Strasbourg. 1,700 feet of 35 mm. film was used to record geodetic material which was found in various universities and other places. These included the triangulation records of Wurttemberg together with some trig data of Baden and elsewhere. At Strasbourg the "Hough" Team found a complete list of bench marks, river-gauge data, and altitudes along both banks of the Rhine, which was of great value when considering the possible flood conditions which might be encountered.

All data obtained by the "Hough" Team were entered upon card indexes, copies of which were supplied to S.H.A.E.F., the Chief Engineer (Com. Z.), and the army groups, so that they were kept informed of what had been found.

All these "T" Force parties were kept busy during the whole period of operations, but especially when Germany itself was entered, and the headquarters of the various German survey organizations were overrun.

The final phase. (The Rhine to the surrender, March-May, 1945)

FIELD SURVEYS

The Rhine was crossed during March, followed by deep, rapid advances into Germany.

In preparation for the assault crossing, the survey units of all three army groups carried out a considerable amount of survey work of all kinds, some examples of which are now given:—

Surveys for artillery control. 14 Field Survey Company, with 3 General Field Survey Section under command, covered with triangulation a belt about four miles wide along the west bank of the Rhine from Emmerich to Wesel. The object was to check the existing trig data, including points on the east bank, to provide additional control where required for artillery surveys, and to fix by intersection new points on the east side of the river. The methods employed included resection, intersection, new triangulation and traverses. The results of the Canadian Army's trig work during their earlier battle between the Rivers Maas and Rhine were found very useful when establishing common points between the British and Canadian Armies. Further common points were fixed between the Second British and the Ninth U.S. Army. For security reasons the erection of beacons was not allowed, though lamps were permitted. Over 40 points were fixed by intersection across the river and these were not confined to the con-

ventional church spires and towers which, as potential O.P.s, are usually listed as targets for destruction by our own artillery. Objects such as prominent trees and gable ends of white buildings were selected.

One topographical platoon of 2 Canadian Field Survey Company continued to work in support of artillery survey regiments until 8th March when operation "Veritable" was successfully completed. This operation, which was carried out by the First Canadian and Ninth U.S. Armies, cleaned up the approach area to the Rhine in the north between that river and the Maas.

Owing to the rapidity of the advance after the Rhine crossing and the adequacy of the published trig lists, very little R.E. survey work to provide artillery control was either asked for or required during April. In fact, several topographical sections of units in Second Army were employed on sorting overrun German map stores, a task which assumed much importance and difficulty during that period. Even for the crossing of the R. Elbe no R.E. control surveys were needed.

In Holland, topographical sections of 2 Canadian Survey Company continued in support of artillery survey regiments during the operations to clear north-eastern Holland, western Holland, and the Canadian area in north-western Germany.

The activities of the American topographical units were of a similar nature to those of the British and Canadian units in the north. The same factor of rapid movement reduced the general need for engineer control surveys but, owing to the dearth of good trig data in southern Germany, the artillery observation battalions were not so well provided for as in the north. The following brief summary of survey activities in U.S. Seventh Army gives an illustration of how their topographical units were employed during the final few weeks leading up to the surrender:—

Survey platoons of 661, 666, and 679 Engineer Topographical Companies operated in support of the artillery with 6, 15, and 21 Corps respectively. Survey platoons of 656 and 649 Engineer Topographical Battalions operated under army control supporting survey platoons of the corps topographical units. During the month of April engineer topographical units confirmed 50 triangulation stations, established 25 new triangulation stations, 5 radar positions and 100 azimuth stations, ran 210,000 yards of traverse, converted 950 points from Gauss-Kruger to Nord de Guerre co-ordinates, and checked autobahn alignments and classification.

Bridge sites. An important task was the provision of survey data for the construction of semi-permanent bridges over the Rhine, Neder Rhine and Ijssel Rivers. The Canadians placed two topographical sections in support of Canadian Army Troops Engineers for the bridge sites at Emmerich and elsewhere, while with the British Second Army, 521 Field Survey Company undertook the survey work for bridges at Rees and Xanten. The work involved at each site was briefly as follows:—

Five lines across the river, specified by the R.E. bridge construction unit, were measured to an accuracy of two inches in plan length and one inch in relative height.

The soundings along these five lines were measured by the Port Construction and Maintenance Group R.E., after which the final bridge alignment was chosen.

The final alignment was marked on two concrete pillars on each bank and the distances and heights between these marks were measured as above.

Large scale plans (1/2,500) were prepared covering the bridge site, including approaches on both sides of the river, and were contoured at 1-foot vertical interval.

The plan distances were determined by base measurement and triangulation using standardized tapes. It was, of course, necessary that the tapes used by the bridge construction units should be compared with the same standard tape as that used by the survey unit. Relative heights were measured by reciprocal vertical angles across the river, and absolute height by levelling from the nearest known bench mark, after checking the relative accuracy of at least two bench marks near each site. Both at Rees and at Xanten, about ten kilometres of levelling were involved.

TRIANGULATION DATA

During the final few weeks of operations the principal trig-list activity concerned the acquisition of captured enemy data for southern Germany, and its conversion to the allied theatre grid system. The states of Baden, Wurttemberg and Bavaria were never adequately covered, but fortunately the speed and nature of the operations during the final stages did not demand anything very extensive in the form of control surveys, so that the lack of data was not of any material consequence. All field formations were by now in possession of S.H.A.E.F. graphs and tables whereby they could quickly convert for use any new material which they might acquire.

A study was made by S.H.A.E.F. at this time of the available trig data of Denmark in case operations should extend to that country. The Danish values were published, accompanied by a Technical Instruction which contained guiding notes on the proper use of the data, and methods of converting the values to the theatre grid.

MISCELLANEOUS ITEMS

Geodetic Surveys (see Diagrams 9 and 10). Previous reference has been made to the unsatisfactory and uncertain junctions between the national triangulations in western Europe, which jeopardized the computation of a reliable geodetic connection between Great Britain and Germany.

During April, 1945, the final connecting rays back from the French coast to England were successfully observed by an American survey party. This completed the cross-Channel connection which had been begun from the English side in 1940.

Other geodetic observations which were successfully completed were as under:—

- (a) A primary chain between Boulogne and Mount Kemmel linking the new cross-Channel connection with the Belgian primary network.
- (b) Observations between Bruges and Jalhay to link the Belgian primary network with the Dutch and German systems.
- (c) Observations to link the Belgian net in Luxembourg with the adjoining French and German triangulations.

The results of all the above work were sent to the War Office.

Radar surveys. Radar surveys had been started during August, 1944, in the Cherbourg area and, as the armies advanced, new stations were surveyed as far forward as possible. During the period of rapid movement some of these stations were used for only a few days, some not at all, and there was a constant demand for fresh sites to be surveyed on the heels of the retreating enemy. The surveys were controlled by D. Survey 21 Army Group until the end of November, 1944, when S.H.A.E.F. assumed general control of the work over the whole operational area.

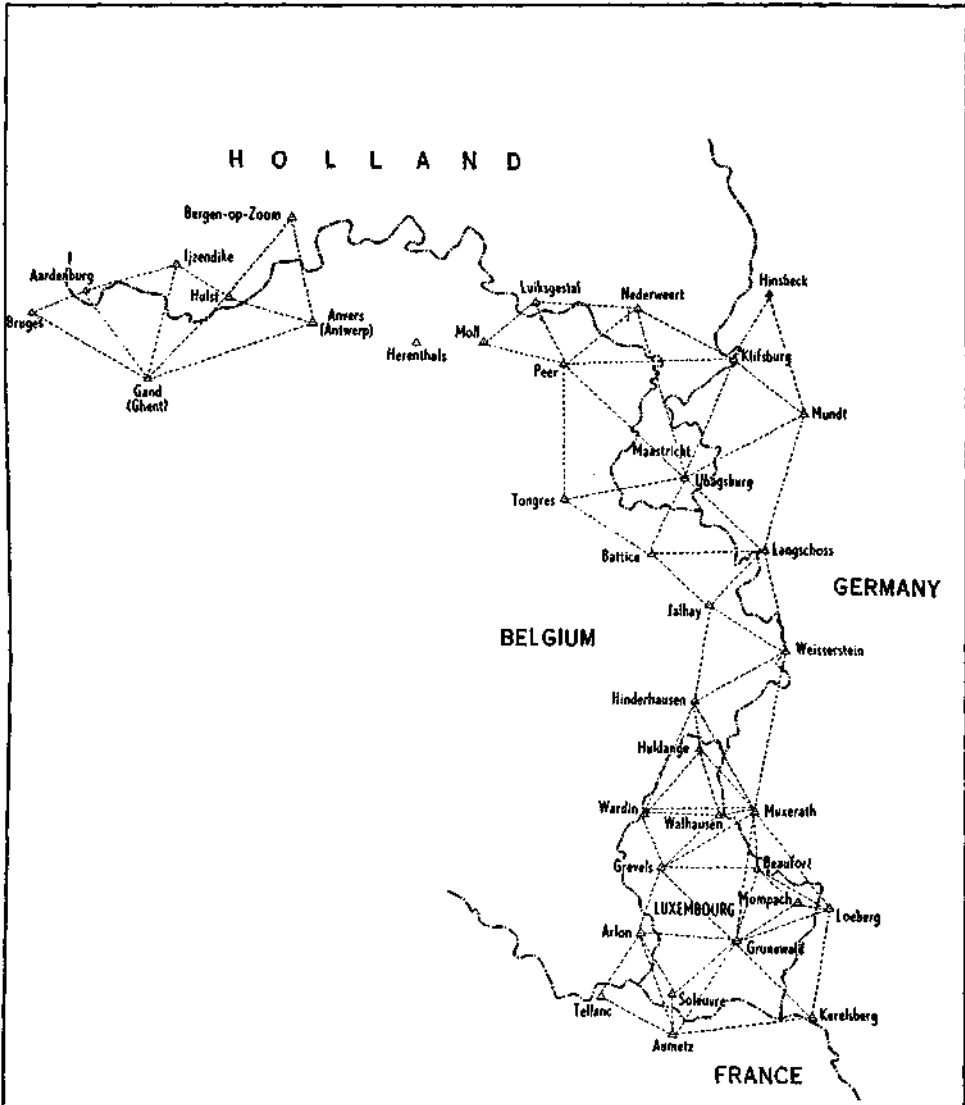
During the autumn of 1944 the topographical sections of 515 Field Survey Company and 4 and 5 General Field Survey Sections were mainly occupied on this work. Topographical sections from survey units with Second Army, Canadian Army, and the U.S. Army Groups were also employed. In addition to those required by the R.A.F., radar surveys were carried out for the artillery in 21 Army Group and also for the Royal Navy. The latter requirement was in connection with navigation in the approaches to Antwerp. Fixation of position was normally effected by resection from existing trig stations or by traverse from them. In the latter case it was always necessary to provide a check by closing on a second trig point or by resection at some intermediate point in the traverse.

Computations were completed to a decimal point of a metre. Geographical co-ordinates were also calculated to two decimal places of a second.

For certain types of radar stations measured panoramas were also required. These consisted of an outline of the skyline from north to south, through east, plotted to a horizontal scale of 15° to one inch, the vertical scale being exaggerated three times, *i.e.*, on a scale of 5° to one inch. The essence of this panorama was to show abrupt changes in the skyline, such as those presented by isolated woods and escarpments. The measurement of the panorama was made by theodolite, reading both horizontal and vertical angles to selected salient features. These points were then plotted and the skyline sketched in by hand. The accuracy aimed at was to about ten minutes of arc.

In these surveys of newly established radar stations speed was an essential factor, and army groups had therefore to maintain a flexible service with a survey party available to go to a specified spot at short notice, meet the R.A.F. representative, and complete the work in the minimum of time.

German national geodetic records. Amongst the principal survey "targets" for the "T" Force teams (including the "Hough" team) on entering Germany were the headquarters and provincial offices of the "Reichsamt für Landesaufnahme," which was the German national survey organization corresponding to the British Ordnance Survey. Their principal geodetic records were discovered at Friedrichroda, together with the chief geodesist (Herr Gigas) and his staff. All the records, together with some of the key personnel, were moved to Bamberg, in the American Zone, where Major Hough had set up his headquarters. Lieutenant-Colonel Browne (geodetic officer with S.H.A.E.F. Survey Directorate) went to Bamberg to interrogate Herr Gigas, and also to Friedrichroda to interrogate General Volmar, who was President of the Reichsamt für Landesaufnahme. Arrangements were made for the German geodetic staff to carry-out certain technical tasks required by the Allies and subsequently to work on a geodetic programme over Germany on which they had previously been employed, and which it was considered would be of value to the occupying forces.



GEODETIC CONNECTION BETWEEN THE TRIANGULATION SYSTEMS OF
 BELGIUM-HOLLAND-FRANCE-LUXEMBOURG-GERMANY

OBSERVATIONS BY 1539th ENGR. BASE SURVEY CO. U.S. ARMY 1944-1945.

Connection between the triangulations of Denmark and Norway (see Diagram 11). As soon as Denmark and Norway had been liberated Brigadier Clough (D. Survey, S.H.A.E.F.), accompanied by Lieutenant-Colonel Browne, visited Copenhagen and Oslo and suggested to Professor Norlund (Danish Geodetic Institute) and to the Norwegian Survey Institute that opportunity should be taken of the prevailing conditions, which were not likely to recur, to effect a junction between their respective triangulations. They were invited to contribute technical personnel and other resources to the extent of their availability, while the allied survey organizations would control the work and provide the balance of personnel and equipment required, supplying also the aircraft, wireless parties and transport which would be required. Reactions to this proposal were favourable and, under Lieutenant-Colonel Browne's supervising control, all arrangements were put in hand for the work to be undertaken. Technical planning conferences were held in Copenhagen at the end of June, attended by representatives of all concerned, in order to draw up detailed plans for the project.

The general idea was that aircraft should fly along the centre of the Skagerrak, dropping a series of flares. From selected existing trig stations along the Danish and Norwegian coasts observations would be taken to these flares, the observations being controlled by a programme of wireless signals.

The increasing use of radar for air navigation seemed to make such a connection between the two systems eminently desirable. The use of radar aids depends essentially on the basic use of accurate geodetic data, and an investigation into the existing triangulation networks of the two countries showed that there was no good junction between them. The modern first-order triangulations of Denmark and Sweden were firmly linked by observations across the intervening water-channel, but those of Sweden and Norway appeared to be connected at one point only, and the identity of that one common point was open to doubt. There was therefore no reliable connection of any sort between Denmark and Norway.

The following gave much valuable assistance towards the successful carrying out of the project:—

Lieutenant-Colonel W. E. Browne, R.E., who was the guiding spirit, technical author of the plan, and in control of the whole operation.

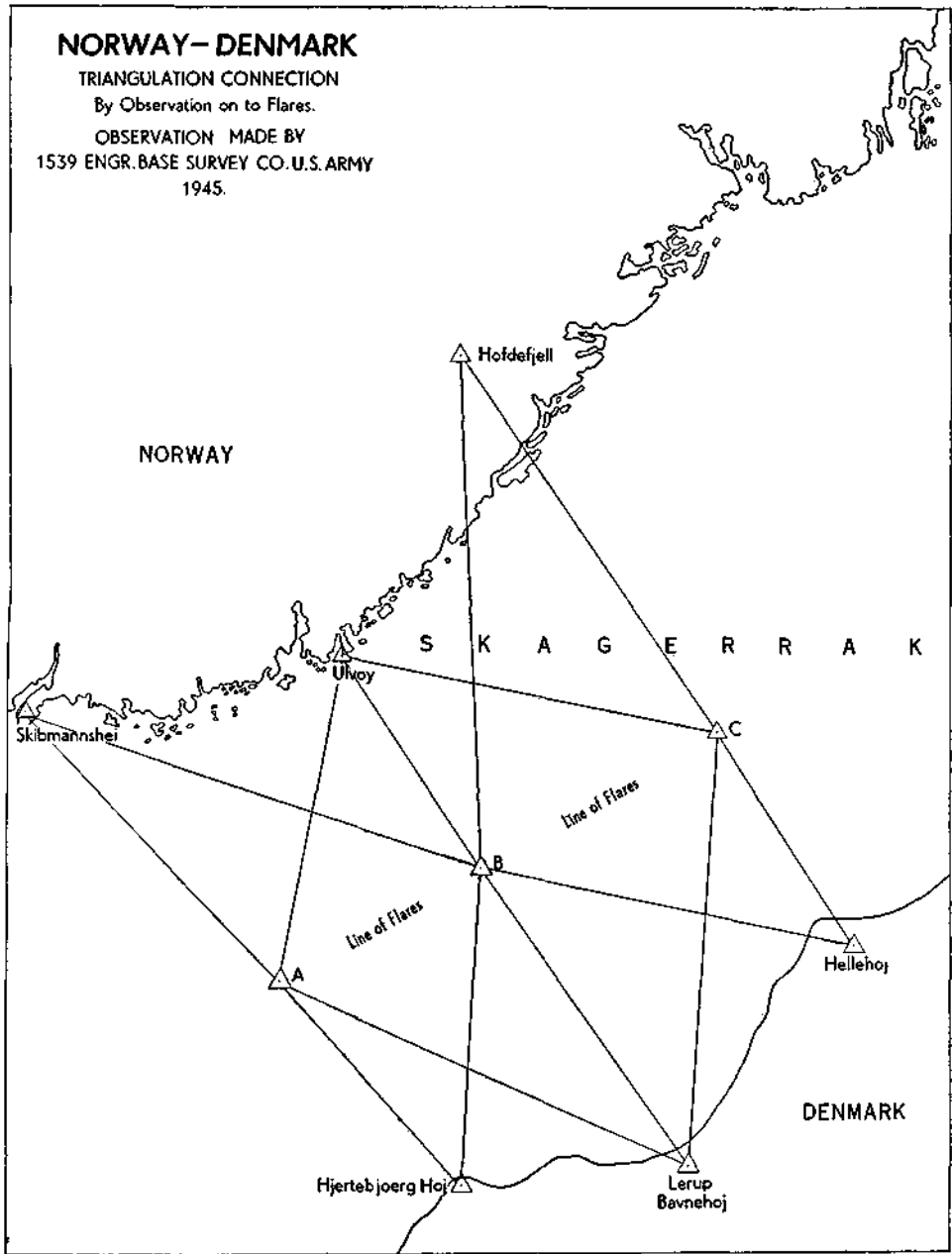
Dr. Norlund, of the Danish Geodetic Institute, and his staff of observers and other technical assistants.

Major Schive of the Norwegian Survey Institute and his staff of observers.

Observing parties from an American Engineer Topographical Battalion serving under the control of Colonel H. Milwit, Chief of Intelligence Division, Office of the Chief Engineer (Com. Z.).

Personnel and radio equipment of the Royal Corps of Signals (21 Army Group). The organization included a centrally controlled broadcast station, with a radio receiving and transmitting station at or near each of the six triangulation stations, three in Denmark and three in Norway.

69 Squadron R.A.F. (2nd Tactical Air Force) with nine Wellington Bombers. This was a night-reconnaissance squadron well experienced in night flying, precision navigation and bombing, all of them valuable assets for the project in hand.



Detailed plans were drawn up governing everybody's activities so as to minimize the risk of failure, and the success of the operation was due to good organization, and the determined and skilful manner in which all concerned did their job.

Yellow parachute flares, with a candlepower of about 230,000, were dropped at an altitude of about 8,000 feet above the sea at predetermined positions, in a series of successive runs. Warning signals were given by the pilot shortly before the dropping of each flare, and the broadcasting station transmitted radio signals. The trig observers at each station, who were provided with headphones, recorded their simultaneous observations on to the flares when they received the "observe" signal. In some cases as many as four "shots" were observed from any one station on to each flare.

The general arrangement of the triangulation connection is illustrated in Diagram 11. All the observing data were sent to the War Office, only approximate rough computations being made in the field, sufficient to detect any gross errors, and to determine the approximate success or otherwise of the undertaking.

The manner in which the final computations are carried out will no doubt depend on the manner in which it may be decided to deal with the major triangulation systems of western Europe as a whole in order to form a solid homogeneous block.

The success of the project indicates that a similar method might be employed for bridging gaps in existing triangulations where local conditions render it difficult by ordinary ground observations to carry forward normal observations. There are several incomplete meridian and parallel arcs of triangulation which might perhaps be completed by this method. Given good weather, the right equipment, and other conditions, gaps of well over 100 miles could probably be bridged. It is of importance to note that a good system of meteorological information is needed.

A full report of the operation is contained in the publication entitled "Triangulation Connection of Norway and Denmark" (by Lieutenant-Colonel W. E. Browne).

Some comments on field survey practice

It has already been noted that, in order to ensure a reasonable degree of standardization regarding some of the basic fundamentals of field surveys, S.H.A.E.F. published an Operation Policy Memorandum on the subject of "Engineer and Artillery Surveys." It may now be of interest to study the following brief summary of field survey practice, including the important item of co-operation between R.E. and R.A. survey, which was adopted by the British Second Army. There will always be divergent views regarding the ways by which successful co-operation can best be achieved. The personal factor is all important and, without this human touch, the best of plans will run the risk of going wrong.

As a general principle R.E. survey work in Second Army was always kept under the control of the Survey Directorate. Topographical sections were never placed under the command of R.A. Survey Regiments, nor were they attached to them for administration, except on the following two special occasions:—

- (a) In Holland, where two topographical sections were at one time attached to survey regiments for the fixation of forward targets beyond R.A. capacity. This was done after all legitimate R.E. survey work had been finished, and when visibility was so bad that the sections had to be on the spot to seize any fleeting opportunity of completing an observation.
- (b) In the Ardennes, where topographical sections were attached to a survey regiment for administration only because of the distance from company H.Q.

The closest liaison was always maintained with R.A. Survey Regiments whenever survey work by R.E. units was likely to be needed. D.D. Survey kept in touch with operational plans at Army H.Q., but artillery planning was decentralized to corps, and it was the duty of the A.D. Survey (who was responsible for the conduct of field surveys within the army) or the corps survey liaison officer to keep in close touch with the R.A. at corps level. As soon as requirements were known, D.D. Survey decided what work should be done and by which unit.

The unit commander was then briefed by the A.D. Survey, who imparted the intention and plans, but in a broad fashion only, so as not to restrict the unit commander's initiative. The latter normally made contact with the second in command of the survey regiment to find out any special requirements before deploying his sections.

Units were never hampered by having the method to be adopted for any task dictated to them. Technical methods within Second Army were, however, standardized by technical instructions, so that sections from different companies could be engaged mutually on any task, *e.g.*—

- (a) Observing procedure was clearly defined.
- (b) Computing forms of standard War Office or Second Army pattern were used, and privately constructed forms were forbidden unless approved by the Survey Directorate and ordered for general adoption.
- (c) In order to ensure that nothing should be forgotten, special forms were produced giving instructions to observers and for recording the data required by the R.A.
- (d) Records and results had to be served up on correct forms, in a standardized sequence, and properly clipped together.

In practice, a large number of survey forms were designed by Second Army, and were approved by Survey Directorate, 21 Army Group for use within the Army Group. The War Office forms had been mostly designed for logarithmic computations.

During the war, surveyors found they had to use different methods and types of forms at the Survey Training Centre, in the Middle East, in western Europe and in other theatres. It would appear to be of great advantage if everyone was taught to use the same methods of observation, forms and records.

Some notes regarding the handling of survey units in Second Army and their organization for field survey work are given below:—

PRELIMINARY ACTION

On first indications of an impending battle, a composite 1/25,000 map was prepared to cover the likely area. All trig points were plotted, and the topo-

graphical officers and serjeants were briefed on it and studied it. At a later stage it was used in the "report centre."

Three 15-cwt. trucks were kept loaded with observers' kits ready to move within half an hour from receipt of orders. The remaining topographical stores likely to be required were sorted and boxed into separate observers' kits. Computing equipment and cooking utensils were similarly sorted and kept prepared.

As soon as orders for work arrived from the Survey Directorate, topographical sections were warned and, when circumstances required it, they were despatched to a rendezvous. The company commander, sometimes accompanied by his topographical officers, then visited the survey regiment to obtain final and full information regarding their requirements. Distances were sometimes so great that this visit took a complete day. As the survey regiments were corps troops they were usually able to secure accommodation more easily than independent sections of army troops units. For this reason they often made the accommodation arrangements for the R.E. topographical sections, especially in the winter months when covered accommodation was particularly difficult to find.

If a rendezvous was ordered, it was usually a map spot close to the R.A. report centre, and the time appointed for it was two or three hours after the estimated time of arrival of the R.E. officers at Survey Regiment H.Q. After the meeting one topographical officer made a quick preliminary reconnaissance of the ground, while the other guided the sections to their accommodation.

ORGANIZATION FOR TRIANGULATION

Depending on circumstances, and on the individual wishes of unit commanders, the two topographical sections were either amalgamated into one under the direct control of the O.C., or they worked independently. In the former case both section officers were able to remain permanently in the field. In the latter case the two sections usually worked outwards from a common line, and after about six stations had been reconnoitred, the two officers met to ensure co-ordination, and the six observing pairs were posted to their stations.

For the preliminary reconnaissance each officer usually took one observer complete with truck to assist him, but after the observers had been posted the officer worked alone, using either a despatch rider to send back details of further selected points to be occupied or observed, or returning himself if sufficient points were already prepared to keep the observers busy for some time.

Each observing pair consisted of a surveyor (trig), a surveyor (topographical), a driver, and a 15-cwt. truck. They received their instructions from, and were supervised by, the trig corporal. A despatch rider made a round of the observing pairs, collected observation results, and took them to the report centre after meeting the trig corporal at an appointed rendezvous. This D.R. was either one of the H.Q. drivers, or was borrowed from a reproduction section.

The report and computing centres were in adjacent tents or rooms, as near as possible to the R.A. report centre. No visitors were allowed into the computing centre. At the report centre a medium scale map and a trig diagram were kept up to date to show the progress of the work. A third topographical officer or, if not available, one of the section serjeants, controlled the report and computing centres. He dealt with visitors and supervised the computing.

ORGANIZATION FOR TRAVERSE

If both sections were engaged on one long traverse they worked independently from either end, tying in at the middle.

The section officer usually made the reconnaissance accompanied by an observer. Stations were marked by banderoles, and at each station instructions were given about which points outside the traverse were to be observed as check rays.

The traverse party consisted of six men:—

- 1 forward picket-man for marking and erecting stations.
- 2 observers.
- 2 tapemen.
- 1 rear picket-man, for bringing forward the rear tripod.

The computing centre was sometimes static and sometimes mobile in a 15-cwt. truck, depending on the nature of the ground. Communication with it was by despatch rider as in the case of triangulation.

DATA AND RECORDS

Values, clearly marked "provisional," were given to the R.A. as soon as available. In addition, a report including co-ordinates of the points fixed during the day was supplied each evening, marked either as "provisional" or as "final" list of co-ordinates.

Computing generally kept pace with observing, but the preparation of descriptions and office abstracts was not usually finished until 24 or 36 hours later.

The final records for the Survey Directorate, compiled in accordance with Second Army technical instructions, were not ready for submission until about a week after the finishing of the field work. They consisted of the following documents:—

General information.

- Description of the task, giving full particulars.
- Unit which did the job.
- Dates when job began and ended.
- Short description of the procedure and methods adopted.
- Important technical points for consideration if the job were to be continued or a new one based upon it.

Diagrams.

- A 1/250,000 map to show the area covered.
- A 1/50,000 map to show stations occupied, points intersected, rays observed, etc.
- A tracing, if necessary, in amplification of above.

List of co-ordinates.

Field-work.

- Angle-book sheets in original.
- Field abstract.
- Fair-drawn descriptions.

Computations:—

The "machine" copy.

Computation diary.

Computation index.

Statement of misclosures of triangles (as a check on the unit's classification of points).

ADMINISTRATION OF DETACHED TOPOGRAPHICAL SECTIONS

The transport corporal was detached with the topographical sections. In addition to maintaining the transport in efficient condition, he looked after the general administration including rations, petrol, oil, etc. This freed the technical N.C.O.s for their survey work. The instrument mechanic also accompanied the topographical sections, and was more often than not available to assist in administrative duties.

Wherever possible rations, petrol and oil came direct from Company H.Q. Dependence on other units, which were liable to move with little or no warning, was unsatisfactory, as the section officer then had to make fresh arrangements, thus prejudicing the prosecution of the work. This centralized procedure was, however, a strain on the M.T. resources of the unit because, with the topographical sections out in the field, only the 3-ton vehicles and the utility vehicles remained at H.Q. Experience showed that field parties should be equipped with 4×4 trucks for their work. The jeep, or something like it, proved its worth many times over.

TECHNICAL METHODS

Observing procedure.

Every angle was booked in full.

One round of observations (face left swing right, followed by face right swing left).

A maximum of six observed stations each round.

Rounds closed always to the reference object.

Separate abstracts for each change of reference object at any station.

Vertical angles always observed. Face right and face left observations to follow each other immediately, and to be recorded one above the other in the angle book.

Traversing procedure.

Azimuth observations were taken, when possible, at each eighth or ninth station in addition to check rays. The latter were plotted graphically to enable an error to be ascribed quickly to one leg and observations repeated if necessary.

Computing procedure.

Computations were duplicated by machines working independently. A logarithmic check took too long.

Astronomical observations.

Stars (Polaris) and the sun (hour angle) were used for azimuth observations.

Resection and intersection.

Semi-graphic methods were mostly used. When the number of rays exceeded about eight, or when the trig control was unreliable, the "Thomas" least-square method of computation was used.

It was found that four or five well-placed resections were enough to check 20 or 30 trig points, and to fix six to ten new points by intersection.

SECTION 4. AIR PHOTOGRAPHY FOR MAPPING AND REVISION

Photography in France and Belgium during the 1939-40 B.E.F. operations

In spite of the experience gained during the 1914-18 war, when the technique of mapping from air-photos for military purposes was first developed and proved so valuable, Air Ministry policy during the between-war years did not appear to encourage the use of R.A.F. aircraft or pilots for the specialized form of air photography required for survey purposes. The Ordnance Survey of Great Britain, which required large areas to be photographed for its extensive programme of national mapping, had to depend on commercial flying firms. The effect of this was that, on the outbreak of war, few pilots had had any opportunity of training in the particular technique required, and the aircraft, cameras and other equipment were not suitable for the purpose in view.

It is true that, on mobilization, one flight of No. 53 Squadron (Army Co-operation), equipped with Blenheim aircraft and F-24 cameras (5 inch × 5 inch) was earmarked for air survey photography as one of its duties but, being part of a normal Army Co-operation Squadron, it was available for other work which might be considered to have greater priority, and its availability for survey photography was at all times uncertain. Apart from this provision no action had been taken to arrange for early and urgent photography in likely overseas theatres where large scale maps were non-existent, where the small scale maps were out of date, and where the advantages of getting the photographs taken early before enemy air opposition became too strong were obvious.

On arrival in France in September, 1939, D. Survey B.E.F. had asked for photography to be undertaken of the concentration area extending from the Belgian frontier westwards to Doullens and St. Pol. The objects of this project were primarily to enable the existing 1/25,000 maps to be revised and some new sheets produced where there were some gaps, but it was also intended to afford training experience to pilots who had no previous experience in this special form of air photography, and to provide training for the survey draughtsmen, many of whom were not well acquainted with the technique of mapping from air-photos. After many delays the photography was carried out, but there was a good deal of wasted time and film owing to faulty navigation.

Owing to the Belgian policy of neutrality it was not possible, during the months before the German offensive, to arrange for systematic photography over Belgium, but limited areas were photographed for intelligence purposes by high-speed aircraft flying at high altitudes, and there were constant missions along the Siegfried Line defences in western Germany. Although not suitable for new mapping these photos were used for defence overprints and for revision purposes.

In anticipation of an allied advance into Belgium in the event of a German offensive, arrangements were made for a programme of photography by the

survey flight of 53 Squadron to take effect from the date on which the B.E.F. crossed the Belgian frontier. The project covered the B.E.F. concentration area along the River Dyle, and westwards from there to the French frontier, with priority given to the successive river lines in between. Most of this photography was completed, and proved to be of great value later when the maps of Belgium were being revised for "Overlord."

When the B.E.F. returned to the United Kingdom in June, 1940, 53 Squadron was transferred to Coastal Command for non-photographic duties, and the special survey flight disappeared. Thus the G.S.G.S., with its increasing responsibilities for providing maps for all possible theatres, was deprived of any special resources for obtaining air-photos for mapping purposes.

The above represents the survey photographic situation for western Europe when, during the early months of 1942, plans were being considered for a return to the Continent, and mapping preparations for such an operation were being initiated.

Photo supply situation from 1940 to 1942

After Dunkirk, when Britain was threatened with invasion, Photographic Reconnaissance Units (P.R.U.) of the R.A.F. were engaged on a big programme of photography largely concerned with the movement of enemy shipping, industrial development, bomb-damage assessment and enemy airfield construction. From the survey point of view these photographs were better than nothing and were, in fact, the only ones available. But intelligence reconnaissance photos are not survey photos, the latter having to conform to certain specifications with regard to the straightness of the runs, scale, overlaps and absence of tilt. They are also required to give complete cover of a specified area, and reconnaissance photography is usually of a patchwork nature. The reconnaissance photos covered only a small part of the area in which G.S.G.S. was interested for its mapping preparations, and were suitable only for a somewhat patchy revision. They were of no use whatever for the production of new 1/25,000 maps of northern France, which were essential for the projected invasion operations.

In April, 1941, a survey officer was appointed to deal specifically with the problem of air-photo supply for survey purposes. He was attached to H.Q., Army Co-operation Command and found that the necessary types of aircraft, cameras and other equipment were not available. Furthermore the Command would not accept responsibility for the provision of special photography for survey purposes.

This situation may have been aggravated by the fact that a particular type of gridded oblique photo, as an aid to artillery technique, was receiving at that time considerable attention, and several squadrons were equipped for photography in connection with this system. The situation was an anomalous one because in any case the system required the use of 1/25,000 maps, and, except for Belgium and Germany, and some very limited areas in the extreme north-east of France, there were no large scale maps available, and air survey photographs were the only possible basic material from which to make them.

For about 12 months no real progress was made regarding policy or action for the provision of survey photography in western Europe, and in the Middle East the Director of Survey was faced with similar difficulties until No. 60 South African Squadron became available from East Africa.

Initiation of the 1/25,000 (Benson) series covering northern France

As part of the early planning in 1942 for a return to the Continent it was decided to initiate the production of 1/25,000 maps of Normandy and other areas in northern France. It will be remembered that the only areas of France which had been mapped by the French on 1/20,000 scale were those along the eastern frontier and those immediately surrounding some of the principal naval bases such as Brest and Cherbourg, and Paris itself.

D. Survey at G.H.Q. Home Forces, by agreement with G.S.G.S., assumed responsibility for this programme, and his first task was to obtain properly flown air survey photos of the area concerned.

140 Squadron R.A.F. and No. 1 Air Survey Liaison Section R.E.

At that time 140 Squadron R.A.F., located at Mount Farm (Benson) near Oxford was employed on photo reconnaissance duties under the operational control of G.H.Q. Home Forces. The operational urgency of the mapping task was recognized and authority was obtained for this squadron to undertake the photography. Seldom was the survey service better served. Though handicapped at first by lack of suitable aircraft for the job, and the absence of previous experience in the particular technique involved, the pilots of this squadron, under the enthusiastic leadership of their then commanding officer, Wing Commander le Mesurier, D.S.O., D.F.C., showed the utmost keenness, gallantry and determination to complete whatever task was asked of them. These tasks included strip photography for mapping, photography for beach-gradient determination, and the photography of potential airfield sites in the invasion area.

To assist in this project, a section of R.E. topographical draughtsmen, which had been formed previously for beach-gradient investigation, moved to Mount Farm in July, 1942, and was located alongside 140 Squadron. Apart from the beach-gradient work which continued, its duties comprised the technical briefing of pilots for the daily survey flights, the plotting of sortie diagrams, and the distribution of photo-prints to the survey units employed on the mapping. In November it was properly established as No. 1 Air Survey Liaison Section R.E., and the happiest relations were at all times maintained with 140 Squadron.

Equipment (aircraft and cameras)

Until the middle of 1943, when it was incorporated in 34 Wing R.A.F., 140 Squadron was equipped with Spitfires (Mark IV and V), and the following cameras:—

		<i>Focal length</i>
Verticals.	K-8 A.B. (Fairchild)	12-inch.
	F-52	36- and 20-inch.
	F-24	5-, 8-, 14- and 20-inch.
Split	F-52	36- and 20-inch.
Oblique.	F-24	8- and 14-inch.

For the first few months of the 1/25,000 (Benson) photography the K-8 A.B. (12-inch) camera alone was used which, at a flying height of 25,000 to 30,000 feet, gave pictures on a scale approximating to that of the finished map. At this large scale, which was admirable for detail interpretation, a large number

of runs and individual photographs was required to cover a given area. At a later date, in order to meet the requirements of the American topographical units with their Multiplex plotting apparatus, K-17 6-inch cameras were used, either alone or accompanied by a 12-inch camera. This provided a more economical coverage.

The aircraft were unarmed, and depended on their high performance for evading enemy opposition. With no observer, the pilot had more than a full-time job trying to keep on his straight photographic course, while keeping an eye open for hostile aircraft and controlling his camera. The Spitfire was in many ways unsatisfactory for this task.

In July, 1943, 140 Squadron was incorporated in 34 Wing R.A.F. and was re-equipped with Mosquito IX aircraft. Eight of these were adapted to take two vertical cameras, one K-17 6-inch and one K-8 A.B. 12-inch. As the Mosquito carried a crew of two, it was well suited for survey photographic work. It had high performance and a good range, the observer was able to assist in navigation, and he was also able to keep an eye open for enemy planes and look after the cameras in operation.

Photographic programme for the 1/25,000 (Benson) series

The area of northern France, over which 1/25,000 maps were required in the first place, extended westwards from a north-south line joining Calais to Paris. This included the coastal district of the Pas de Calais, the whole of Normandy as far south as the R. Loire, and the Brittany peninsula. To conform with the invasion plan which was being developed, this area was divided into three priority sub-areas, and the dates of the beginning and the completion of the photographic sorties were as shown below:—

First priority:—Comprising the Pas de Calais coastal zone and the Normandy invasion assault area to a depth of about 60 miles.

Photography begun	24th July, 1942.
Photography completed	16th September, 1942.
Number of sorties	210

Second priority:—Covering the Brittany Peninsula.

Photography begun	16th September, 1942.
Photography completed	14th April, 1943.
Number of sorties	77

Third priority:—Extending the first priority area southwards to the R. Loire.

Photography begun	15th April, 1943.
Photography completed	17th August, 1943.
Number of sorties	55

The above summarizes the R.A.F. contribution to the "Benson" mapping project. On the arrival of photographic squadrons of the U.S. Army Air Force arrangements were made for them to take a share in the work.

Photography for the determination of beach gradients. (See also Chapter XIV, Section 10.)

In January, 1942, Survey was asked to assist in the problem of determining the gradients of enemy beaches. It was decided, as a first measure, to carry

out experiments involving the photography of selected beaches in the United Kingdom. The horizontal distances between the water-lines at various stages of the tide could be measured on vertical photographs taken at predetermined intervals, and differences in tide heights computed from tide-tables. The experimental results proving satisfactory, a programme of photography along the beaches of northern France was drawn up. For the intricate problem of examining the photographs and measuring up the water-line distances a section of about 12 R.E. draughtsmen was formed. The section officer prepared the timed sortie programmes and briefed the pilots for each flight. Work was begun on 30th April, 1942, the section later moving down to Mount Farm (Benson) where it received establishment status as No. 1 Air Survey Liaison Section R.E., already referred to above.

The photography was shared between 140 Squadron R.A.F. (Benson) and a Photo Reconnaissance Flight based at St. Eval in Cornwall. The technique consisted of photographing the beaches at high and low spring tides and at four uniformly intermediate periods. With the vagaries of the weather, the need for meticulous timing, the necessity for fitting in with other R.A.F. operations in the same areas, and the preservation of security, it can well be imagined that the completion of the necessary sorties over any particular beach was a difficult and sometimes a lengthy job.

Flying began on 6th May, 1942, and was completed on 12th May, 1944. By "D"-day (6th June, 1944) a total of over 200 different beaches had been photographed and their gradients determined. This involved a total of close on 500 sorties of which nearly 380 were flown by 34 Wing (140 Squadron) and the remainder by the squadron at St. Eval. To the former were allotted the beaches between Flushing and St. Malo, and the latter extended the photography along the Brittany coast to the vicinity of St. Nazaire.

In addition to the water-line method some determinations were made by the measurement of wave velocities from air-photos. This involved about 20 sorties during early 1944.

Photography of potential airfield sites

The rapid development of landing strips and airfields in the invasion area after the assault landing was clearly going to be a matter of vital importance. This produced a demand for air surveys of potential sites from which plans could be worked out for the engineering and other work that would be required. The technical aspects of this problem as they affected Survey are dealt with in Section 5 of this chapter.

Mapping photography over north-western France by the U.S. Army Air Force and U.S. policy in connection therewith

When Brigadier Hotine (Director of Military Survey, War Office) visited Washington in May, 1942, to discuss allied mapping problems with the topographical authorities of the War Department (*see* Chapter IV), he asked them to assist in the early preparations for "Overlord" by sending over an officer experienced in modern photogrammetric methods, and the necessary technical personnel to help in the production of 1/25,000 maps from air photographs. The War Department agreed to do this, and agreed also to arrange for the early provision of mapping squadron aircraft.

Colonel H. Milwit (Corps of Engineers) arrived in the United Kingdom

in June, 1942, and, after acquainting himself with the current mapping situation, he drew up a memorandum for his Chief Engineer (E.T.O.U.S.A.) on the mapping problem as he saw it. In this memorandum he described the methods being used by the R.A.F. for obtaining survey photographs, pointing out that, although they might be suitable for the mapping technique at that time being employed by British survey units, they could not be used in conjunction with the Multiplex stereoscopic apparatus with which the U.S. Engineer Topographical units were equipped and for which their personnel was being trained. He urged that, as weather conditions suitable for mapping photography could not be expected after September, immediate action should be taken to provide photographic aircraft in the European theatre equipped with K-17 (6-inch wide angle lens) cameras of the type necessary for Multiplex mapping, with K-18 (24-inch) cameras additional for obtaining larger scale photos required for interpretation of detail and for making up mosaics and photo-maps. He recommended that one photo-mapping company of a G.H.Q. topographical battalion, and one army topographical battalion, should be scheduled for arrival in the United Kingdom not later than mid-August. The Chief Engineer (E.T.O.U.S.A.) endorsed this proposal, which was agreed to by the War Department, who stated that four B-17 aircraft, complete with crews and camera equipment, would be despatched to the United Kingdom for air survey photography. They duly arrived but, before they could be employed on any survey photographic missions over France, they were transferred to North Africa for service on operation "Torch." This was unfortunate, as it meant that the American topographical units in the United Kingdom had no air photographs suitable for use with their Multiplex map plotting equipment. They had therefore to use R.A.F. photographs taken with the 12-inch Fairchild cameras, and they were allotted blocks of sheets in the 1/25,000 (Benson) project.

Company B of 660 Engineer Topographical Battalion, to whom were allotted these blocks of 1/25,000 sheets in the Cherbourg and Caen areas, received the photographs from the British Air Survey Group together with the necessary horizontal and vertical control data. They used the slotted template method of establishing further control, and employed vertical reflecting projectors for plotting the planimetry. The resulting map, as in the case of those sheets produced by the British survey units, was of reasonably high accuracy, and entirely adequate for the purpose in view. It cannot be doubted, however, that the compilation would have been easier and quicker if K-17 (6-inch) photos had been available for use with the Multiplex plotters.

There was no further action regarding photography by American aircraft till January, 1943, when Colonel Milwit again raised the matter with the Eighth U.S. Air Force. The Commanding General indicated his interest and desire to assist in the production of the required survey photography.

Meanwhile, in January, 1943, a conference was held in London, attended by British and American representatives, to discuss future mapping programmes and the air survey photography required in connection therewith. At that date the R.A.F. photography of the first-priority areas including the coastal districts of the Normandy invasion area, was nearing completion, and the Brittany peninsula had been started. Spitfires had been used for this work, and with their limited range it was not anticipated that much additional photography outside those areas could be obtained. It was also clear that the preparation of 1/25,000 maps in the Normandy area could not be completed till the end of 1943 at earliest. The British recommendation was that it was

neither necessary nor desirable to duplicate the photography already obtained by the R.A.F. over Normandy and north-eastern France, and that any photography by American aircraft which might become available should be concentrated outside that area. After due consideration of all the factors involved it was decided that the first priority for American mapping photography, when available, should be the Brittany peninsula, followed by the Atlantic coastal area of western France extending southwards from Nantes.

On 22nd June, 1943, No. 13 Photo Squadron flew its first mission using Lockheed Lightning aircraft fitted with K-17 (6-inch) cameras. During the remainder of 1943 this squadron successfully completed Multiplex photography over more than 10,000 square miles without loss.

It was found, however, that the Lockheed Lightning was not the proper answer to the mapping problem, as it was difficult for the pilot of a single-seater aircraft to maintain accurate flight lines, manipulate his cameras and keep his eyes open for hostile aircraft. This confirmed the experience of the R.A.F. using Spitfires, and was one of the reasons why the latter were replaced by Mosquitoes with a crew of two when they became available.

Once started, the programme for covering the Brittany peninsula, the French western seaboard, and other probable operational areas in northern France went ahead quickly and enabled the 1/25,000 (Benson) mapping, and also an extensive photo-map project, to be completed just in time for "D"-day.

In December, 1943, an effort had been made to insure against the diversion of American photographic aircraft from mapping missions, and a request was made that certain photo squadrons should be assigned for the sole purpose of obtaining mapping photographs. A conference on air-photo requirements was convened by the Commanding General E.T.O.U.S.A. late in December at which, although there was some adverse comment regarding the small amount of air photography being provided for the theatre, there were protests from other quarters against the diversion of tactical aircraft to photo missions. The Engineer of 12 U.S. Army Group and Colonel Milwit stated at this conference what aircraft were needed to provide the necessary mapping photography.

The theatre commander directed that action be taken to provide two mapping squadrons for the theatre. The air force representatives, however, did not wish to allocate squadrons for the exclusive purpose of securing mapping photography for the topographical engineers, and continued to present arguments against such action, coupled with an assurance that all mapping requirements could and would be handled by the existing organization without the need for allocating special squadrons. The theatre commander thereupon reversed his decision.

At that time, as previously described, considerable effort was being applied to photography for the 1/25,000 mapping and revision projects in western Europe, but there was always the fear that conflicting requirements, especially after military operations on the Continent had started, would cause mapping photography to be sidetracked, and the aircraft switched over to other duties. This anxiety was confirmed by later events when, in spite of their commitments for providing the mapping photography required, the entire air photographic resources were employed on intelligence reconnaissance missions during the vital period of good weather between June and September, 1944. The urgent map-revision project for Germany and a new mapping programme to cover an unmapped gap in Bavaria with 1/25,000 maps suffered from the

delay, and all subsequent efforts to catch up were hindered by bad weather and other factors until the latter part of April, 1945, when it was too late.

With a view to the consideration of future requirements, it may be of interest and value to quote the following extracts from a report written by the Engineer 12th U.S. Army Group in May, 1945:—

“In spite of the great importance of maps, the basic mapping photography required for their production has not been adequately provided in this theatre. Mapping photographic projects laid on as early as March, 1944, had not been completed by March, 1945. One project covering a gap in the Bavarian map series was laid on in September of 1944. In March of 1945 only 50 per cent (approximately) of the area had been covered. The failure of the air forces to prosecute mapping photography made it impossible for topographic units to revise the operational maps of much of Germany east of Kassel. Fortunately the advance of our troops was so rapid that large scale maps were not absolutely essential. Had the situation been otherwise, serious repercussions from the field forces would have been felt.

“The Corps of Engineers had long advocated that a certain number of squadrons be earmarked for mapping purposes only. Heretofore the air forces have always insisted that such an earmarking of squadrons was unnecessary and uneconomical and that mapping photography could and would be procured when required. Experience has indicated that such is not the case.”

Although noting the above adverse comments regarding the prosecution of systematic mapping photography, it must be recorded that a great amount of 6-inch (K-17) Multiplex photography was undertaken by American photo squadrons, especially those of 7th Photo Reconnaissance Group. By the close of hostilities practically the whole of northern France, Belgium, Holland and a large part of Germany west of Berlin had been covered. There were, however, many gaps, and much of the photography was too late for use on mapping projects required to keep pace with military operations. Supplementary partial cover was also obtained with 12-inch and 24-inch focal length cameras which was of much value for interpretation purposes.

Western Austria was also covered by 6-inch photography flown by the Provisional Reconnaissance Group of Ninth Army Air Force for the purpose of compiling new 1/25,000 maps of that area.

The control of mapping photographic programmes overseas

In 1942, when the 1/25,000 (Benson) mapping project was started, the photographic programme was drawn up by D. Survey Home Forces, and later controlled by D. Survey 21 Army Group when the latter formation was made operational. Early in 1944, when S.H.A.E.F. and the Headquarters of the Allied Expeditionary Air Force (A.E.A.F.) were established for the command and control of allied ground and air forces for “Overlord,” the responsibility for the organization of mapping photography for the theatre as a whole devolved on the Director of Survey (S.H.A.E.F.).

The advent of American resources in photographic squadrons and topographical units, made it essential that D. Survey (S.H.A.E.F.) should maintain the closest liaison with Colonel Milwit, who was the technical head of the U.S. topographical organization within the theatre. With his co-operation speci-

fications and areas of priority for the photographic programmes were drawn up and submitted through G-2 (S.H.A.E.F.) to H.Q. A.E.A.F. (later S.H.A.E.F./Air), who made the necessary arrangements for the photography to be undertaken by photo squadrons under its control overseas or by units in the United Kingdom.

For "Overlord" the British 2nd Tactical Air Force (T.A.F.) operated with 21 Army Group, and units of the Tactical Air Forces of Ninth U.S.A.A.F. operated with American forces in the field. These air forces included photo squadrons which undertook local missions to meet their own army group and army photographic requirements, mainly for intelligence purposes. In 2nd. T.A.F. was 34 Wing, operating directly under H.Q. 21 Army Group. In this wing was 140 Squadron which, it will be remembered, had produced so much photography of northern France which was used for the 1/25,000 (Benson) map series. 21 Army Group Survey was therefore able to arrange for any specific local missions of mapping photography which were required. Examples of this included the photography of the Seine and Somme defence positions for large scale mapping, the Frisian Islands for their re-mapping, and certain beaches off the German and Dutch coasts for beach-gradient determination.

Speaking generally, however, the mapping photography of western Europe for revision and new mapping on a theatre basis was controlled centrally from S.H.A.E.F. through the Air Staff, with close co-operation from Com. Z. This undoubtedly led to a prevention of duplication and overlap.

Army groups and armies frequently found it desirable to make use of large scale intelligence photos to assist in detail interpretation during their revision and mapping projects, and for this purpose they made considerable use of photography obtained by squadrons under their control. To keep those concerned in the picture with regard to the progress of the theatre photographic programme, reproductions of basic photo-cover diagrams, prepared by Com. Z. on 1/250,000 sheets, were regularly circulated. The photographic library of the Central Interpretation Unit (C.I.U.) at Medmenham was also a valuable source of photographic data.

SECTION 5. RECONNAISSANCE SURVEYS OF POTENTIAL AIRFIELD SITES

Requirement

When planning for "Overlord" one of the principal factors under consideration was the question of air-support for operations subsequent to the assault landing on the Normandy coast. The distance from existing airfields in southern England to the operational area was such that fighter aircraft based on those airfields would have a very limited operational period over the battle-zone owing to the petrol consumption involved during the outward and return journeys. It was essential therefore to establish landing grounds and airfields overseas as early as possible.

To save time on reconnaissance after landing, and to be able to make all possible preparations beforehand regarding the engineer work which would probably be required, it was decided to try and determine the most suitable locations for the landing strips and airfields from a study of existing maps and air photographs. The Director of Survey Home Forces was asked to assist in this work and to prepare detailed maps of the sites.

The specified requirement was for a large scale contoured map of each selected site which would show all relevant natural and artificial features. Along each provisionally selected runway spot heights were needed at close intervals, so that gradients could be determined and estimates made of the amount of excavation and filling likely to be required.

Research

It was in December, 1942, that this project was formulated and, at that time, the mapping company of the U.S. 660th Engineer Topographical Battalion had recently arrived in the United Kingdom with its Multiplex plotting equipment. It was installed at Kew and was working in close liaison with the Director of Survey Home Forces. The plotting of detail and height determination from air-photos by Multiplex offered possibilities of obtaining the required standard of accuracy.

As a result of discussion between British and U.S. survey officers, it was decided to conduct tests from which to draw up specifications for air photography, and to decide on the best method of plotting from the photos. This test was carried out over a specially surveyed area so that a comparison could be made between the results obtained by photogrammetric methods and those obtained from a ground survey in which all facilities existed for getting a correct answer. Photographic sorties were flown at 6,000, 9,000, and 12,000 feet, using a K-17 (6-inch) camera, and test sheets were compiled at scales of 1/5,000, 1/7,500, and 1/10,000. As a result it was agreed that Multiplex compilation was the best method because of its speed and accuracy. It was agreed also that the plans should be at 1/10,000 scale, with contours at 5-foot vertical interval, and spot heights covering the runway areas at intervals of 100 metres.

Procedure

The provisional sites having been selected by the planning staffs from 1/50,000 maps and reconnaissance photos (the 1/25,000 maps had not at that early date been produced), their locations were notified to D. Survey, who instructed his Air Survey Liaison Officer to lay out the necessary flight lines and to brief the pilots for their sorties. Photography was undertaken by the Photo Reconnaissance Unit at Benson which used Mosquito aircraft fitted with K-17 (6-inch) cameras. The flight lines were laid out so as to embrace as many sites as possible in one sortie, and steps were taken to provide security cover. The aircraft flew over the Channel and the French coast at 30,000 feet, then dived to 12,000 feet for the photographic run, and so home. Prints of the sorties were made at once and sent to the mapping company who determined their acceptability. If acceptable, as was the case for over 90 per cent of the flights, prints and the original negatives were delivered to the unit within 24 hours. Occasionally, it was necessary to re-fly a sortie owing to poor photography, or because some vital points of control had been missed. Co-operation between the U.S. mapping unit and the R.A.F. was excellent.

Provision of "control" for the compilation offered a difficult problem. For the planimetry, use was made of enlarged detail from the French 1/80,000 map, and selected triangulation points whose co-ordinates were known. For heighting and contouring it was necessary to depend on spot heights shown on the French maps where these could be related to specific points of detail. Fortunately at the northern end of the Cherbourg peninsula there were available

some French 1/10,000 and 1/20,000 maps whose standard of accuracy was high, and these gave excellent control both for plan and heights.

To attain the highest degree of accuracy when using the Multiplex plotting apparatus, and to eliminate the human factor as much as possible, double sets of projectors were set up, and the work of compilation was duplicated, with special reference to the determination of heights which were of such vital importance. When fair-drawn the manuscripts were handed to the Director of Survey, who had them reproduced and printed in colour. Upwards of 120 sites were surveyed in this fashion. (See Diagram 12 and Plate 55.)

SECTION 6. MAP SUPPLY AND DISTRIBUTION

Issues for the assault and early build-up

(a) ASSEMBLY OF BULK MAP STOCKS IN THE UNITED KINGDOM

As the maps for "Overlord" came off the printing presses they were assembled, under War Office control, in four map depots located at Aldershot, Reading, Towcester and Oxford, the first three of which were manned by War Office personnel. The Oxford depot, being for American use, was manned by American personnel. These stocks included large, medium and small scale topographical maps of potential operational areas on the Continent. The Director of Survey (S.H.A.E.F.) kept himself fully informed of the progress of this assembly, and copies of the weekly map stock reports were sent to him.

The flow of maps into the four depots was regulated at No. 8 War Office Map Depot (Hygrade) where the maps passed through various stages of preparation for easy use and handling, and for the safeguarding of "security." They were first rolled in bundles of 50 (with a proportion in bundles of 20 and 10), and were wrapped and labelled, the series and sheet numbers being shown in code. The rolls were then made up into bales of 10 rolls each which were wrapped in hessian material, firmly secured, and then stencilled on the outside with the coded detail of the contents.

(b) PRE-ASSAULT MAP DISTRIBUTION TO BRITISH FORMATIONS

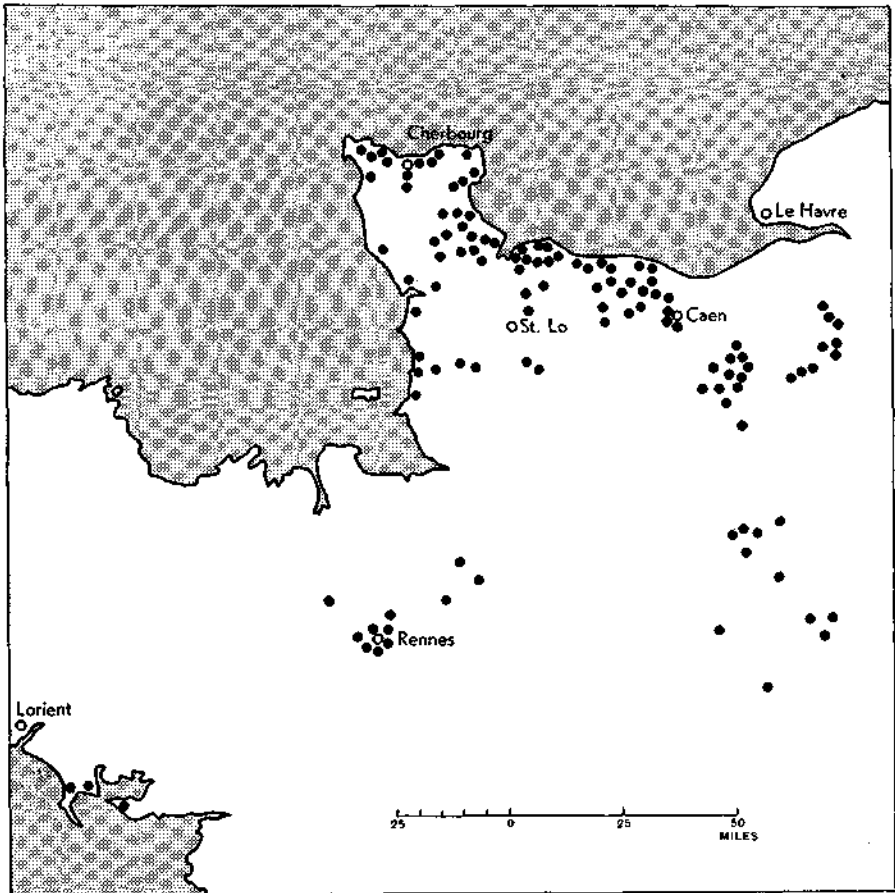
General procedure. S.H.A.E.F. Survey Directorate did not take any direct part in the actual distribution of maps for "Overlord." A training exercise was carried out under 21 Army Group control in connection with various matters concerning the concentration, assembly and embarkation of the assault troops as a result of which plans were drawn up for the issue and distribution of maps to the invasion troops. For the British force detailed arrangements were made between 21 Army Group, Second Army and the War Office. In the case of U.S. forces taking part in the assault, arrangements were made direct between U.S. First Army and the Chief of the Engineer Intelligence Division (O.C.E.) E.T.O.U.S.A., who worked in close touch with D. Survey (S.H.A.E.F.) and the War Office Survey Directorate. The arrangements for assault issues, as will be described below, involved the setting up of a number of special map depots in southern England, and the preparation of a detailed organization for issuing the maps. The successful operation of the map issue plan reflected great credit on all those who planned and carried out the task.

Initial map issues (Second Army). The problem was rendered difficult and complicated by the paramount need for "security." It was ruled that

DIAGRAM 12

SURVEYS OF POTENTIAL AIRFIELD SITES

Location diagram for the Invasion Area



Airfield Sites in Northern France

no maps were to be opened before the expedition had sailed, except by those personnel already briefed during planning.

As stated above, maps supplied by the War Office were in sealed packages, labelled in code. It was, of course, necessary to brief the assault troops for their tasks, and this was done in the marshalling areas on special "security" maps which Survey, Second Army, had prepared. These maps showed correctly the main topographical features, but they carried false names and other devices for disguising the actual location of the assault beaches.

This security aspect applied most vitally to the actual assault troops and the early build-up. For these troops (*see* below, categories A, B, and C), all maps were issued in sealed parcels, with contents marked in code. All lists and schedules were also in code, so that neither the actual issuing staffs in the map depots nor the recipients knew what maps were being issued. Each self-contained unit or detachment which embarked as an entity was given a separate and unique List Index No., and as each of these passed through the marshalling area it collected its own map bundles. There was no difficulty with regard to 8 and 12 Corps who were not due to land until between "D" + 8 and "D" + 12, and they drew their maps in sealed bulk 12 days ahead of their landing dates, for distribution to units from "D"-day onwards. In the case of the R.A.F. also there was no difficulty, as their normal operational stocks already covered the area.

For issue purposes the Force was divided into four categories:—

Category A. Troops embarking in pre-allocated ships.

Category B. Other troops landing up to "D" + 5 (inclusive) who would therefore leave their concentration areas from "D" - 1 to "D" + 2.

Category C. Troops landing from "D" + 6 to "D" + 12.

Category D. Troops landing from "D" + 13 onwards whose concentration areas could not be decided until well after "D"-day.

Category E. Special troops such as "Phantom."

Each category required different treatment as under:—

Category A. The corps concerned drew maps in bulk about "D" - 14. Using personnel already fully briefed, bulk was broken into craft or ship bundles, which were delivered to the O.C. troops of each craft or ship in the marshalling area. Bundles were included for any army troops units who were to sail in pre-allocated shipping. *The maps were not to be opened until after sailing.*

Category B. Troops in this category drew maps according to their List Index No. from the map depots in the marshalling areas. Headquarters of corps drew maps in bulk about "D" - 14 and prepared a bundle for each relevant "List Index No." entitled to draw maps. These bundles were returned, with a list of contents in code, to specified map depots in the marshalling areas. The "List Index Nos." collected their own bundles on passing through the marshalling area.

Army troops, formations, such as A.A. brigades and others, who were in a position to do so, had their maps bundled for them and collected them, as in the case of corps troops.

Category C drew maps, in accordance with a prearranged time-table, from map depots in concentration areas on "D" + 1.

Category D drew maps from map depots in concentration areas as soon as possible after "D" + 2.

Category E drew maps when required from the map store at Main H.Q. 21 Army Group by arrangement with Survey Directorate. Issues were "Top Secret."

Detailed arrangements. A small map depot was established in each of the six marshalling areas and eight concentration areas. Each was commanded by an officer borrowed from the Survey Training Centre R.E., and was manned by personnel from Home Forces survey units. Groups of two to four depots were commanded by a "map subaltern," and they in turn were commanded by a "map captain" who was attached to and located at Second Army Survey Directorate. As a precaution against the destruction of any of the depots by air action a small mobile map depot was held in readiness.

The depots were stocked by the War Office from their main assembly depots about six weeks before "D"-day in accordance with requirements estimated by Second Army. It soon became apparent that the proportion of small rolls (20s and 10s) was insufficient, and the large number of very small detachments who required between two and five sets of maps only made it necessary to break down a quantity of maps into rolls of two maps each in order to avoid waste.

Each formation or unit was provided with a "map issue schedule" showing in detail what it had to draw. Where possible the depot from which, and the time at which, they were to draw was also stated. In some cases it was possible to say only—"from your marshalling (or concentration) area depot on arrival in the area." A duplicate copy of the "map issue schedule" was sent to the relevant depot (and to other relevant depots if the exact one was not known), and also to the Survey Directorate.

There was one major difficulty foreseen which applied to "List Index Nos." in Category B for whom pre-bundling had been carried out. Movement Control could not say with certainty, until 24 hours in advance, into which marshalling area any particular "List Index No." would go, and therefore any individual bundle might easily be in the wrong depot. The following arrangements were therefore made:—

Each marshalling area depot was provided with a "forecast of movement" which enabled the preliminary marshalling of bundles to be arranged in that particular depot which would most probably be the correct one, and also with a "force movement table" which showed the firm movement plan for the following 24 hours. This enabled a final marshalling of bundles to be carried out if any change was necessary.

Each depot was provided with a 15-cwt. truck.

Two liaison officers from units in the late build-up were attached to each marshalling area depot to make sure that units drew their maps correctly. They each had a 15-cwt. truck.

The camp commandant of each marshalling area headquarters was instructed to tell every unit, when reporting to him on arrival, how to obtain their maps.

The operation of the pre-assault map issue plan. As might be expected things went wrong on occasions and difficulties arose which had to be straightened out but, on the whole, the arrangements worked well.

The Second Army planning programme had been governed by a schedule or time-table. In this schedule consideration of map requirements appeared too low down and was, in fact, one of the last items. There was, in consequence, considerable delay before it was possible to reach a reasonably firm conclusion about the numbers of the various maps required. Although appreciating how difficult it was for formations to state what maps they required before their other plans were cut and dried, the delay made it difficult for Survey to place its printing orders and then get the right numbers of the right maps assembled ready for a complicated issue plan.

Some of the formations in Category A failed to inform all their assault units that they would find their maps ready for them in the ships. As a consequence many units went along to the map depots without any "map issue schedules" and demanded maps. A great deal of unnecessary work was caused in checking up that they were in fact Category A troops.

A few units in Category B started to reach marshalling areas before "D"-day, contrary to the information originally conveyed to the Survey Directorate. Maps had, in consequence, to be issued before "D"-day, and the risk of units disobeying orders and opening their map bundles had to be accepted.

Some units in Category C moved from their concentration areas before "D"-day contrary to the original plan of Movement Control. Thus they had to draw their maps from marshalling area depots instead of concentration area depots as planned.

A few units in pre-allocated shipping were reported as having no maps on board, and special arrangements had to be made to issue them with suitable quantities. Similar *ad hoc* arrangements were made for about half a dozen ships which were added to the original concentration at the last moment.

One of the corps omitted all its formation map lorries from its list of requirements for embarkation, so one of the bulk consignments belonging to the Army Field Survey Depot had to be broken in order to make good the deficiency.

One unit, required for early armoured reconnaissance duty, landed in France with insufficient maps for their role owing to the fact that their corps had not demanded enough maps for them. The deficiency was made good by the timely arrival overseas of the Army Field Survey Depot stock.

At 0100 hours on "D"-day a staff officer at H.Q. 21 Army Group informed A.D. Survey that a divisional headquarters had left its maps behind! A.D. Survey obtained the code numbers and other details of the maps concerned and the maps were drawn from a map store in Essex and sent by truck under escort to Southend. They were taken to the end of Southend pier and loaded on to a Naval launch from which they were delivered to the forgetful headquarters in mid-Channel.

In a complicated map distribution plan such as this it will be realized how essential it was to ensure the closest liaison between Survey, the General Staff, Movement Control, and all those others who were concerned with the vital task of seeing that the troops who embarked on their various craft were in possession of everything necessary for the successful carrying out of the operation.

(c) INITIAL MAP ISSUES TO AMERICAN ASSAULT FORMATIONS

Map depots in the United Kingdom. By agreement between the War Office and the War Department, Washington, the former was responsible for providing initial bulk stocks of maps required by U.S. Forces for the early stages

of "Overlord." It was estimated that this provision should extend till about "D" + 90, by which time it seemed probable that direct communication would have been opened up between the United States and French ports. American forces would then assume responsibility for the provision of their own bulk map supplies. In accordance with this programme one of the four main War Office map assembly depots (that at Oxford) was handed over to American control. This depot was stocked with bulk consignments, printed under War Office arrangements, in accordance with a stocking programme which was agreed between D. Survey (S.H.A.E.F.), the Map Distribution Section of the Survey Directorate (War Office) and Colonel Milwit the Chief of the Engineer Intelligence Division (E.T.O.U.S.A.).

This Oxford depot (No. 5), together with another (No. 6) located at Lockerly in Hampshire, were scheduled as Base Map Depots for the assault issues. Two other depots, No. 1 at Cheltenham and No. 4 at Swindon, were scheduled as Transit Map Depots. In addition, nine Marshalling Area Map Depots (M.A.M.D.s) were formed.

The development of the distribution scheme. As plans for the operation became firm, Colonel Milwit, in December, 1943, discussed with the Engineer, First U.S. Army (F.U.S.A.) the formulation of a policy to govern map distribution to units of F.U.S.A. taking part in the assault and follow-up under 21 Army Group control. The policy suggested to the First Army Engineer was that the Chief Engineer (E.T.O.U.S.A.) would supply all necessary maps and transportation, as well as any additional personnel who might be required to effect a detailed breakdown of map stocks for the troops concerned. It was proposed that responsibility for the ultimate breakdown and supply of maps to units and to individual craft should rest with the Army Engineer.

The Engineer (F.U.S.A.) disagreed with this proposal. He maintained that the Services of Supply (S.O.S.) should do the entire job of breakdown and delivery of maps to all units in accordance with an issue plan to be made up by formation Engineers. His argument was that, as S.O.S. was handling all embarkation arrangements, including the assignment of troops to craft, it would be more practical for them to handle also the mapping-up of the assault troops. This threw the entire responsibility back on to E.T.O.U.S.A. This meant that the Chief Engineer would have to be completely informed on operational plans at the earliest possible moment, with all essential information regarding craft loading, including times and points of departure.

Discussion and argument about detailed procedure continued until April, 1944, and the preservation of security presented, as usual, a most difficult problem in working out map issue plans. Finally at a conference held on 14th April, 1944, attended by representatives of the Chief Engineer, the Southern Base Section (S.B.S.), and the Engineer (F.U.S.A.), agreement was reached on the procedure for effecting distribution to the assault units.

The Engineer (F.U.S.A.) was made responsible for preparing detailed map issue lists in code, showing exactly what maps were to be issued to each unit and detachment. The Southern Base Section, which was administratively responsible for the organization of camps in the marshalling areas, indicated which were the camps in which the various units would be marshalled, and which marshalling area map depots would serve individual camps. The detailed issue lists were grouped by camps and marshalling depots so that the Chief

Engineer was able to stock each depot properly and make up bulk orders to fill the requirements of each camp.

In each camp was established, under the control of the static force commander, a camp map depot (C.M.D.) to receive the bulk maps in coded rolls for distribution to individual units within the camp. The mounting plan contemplated that the briefing of assault units would be held before maps were broken down into craft loads. This meant that maps had to be available before briefing time. Unlike the British Second Army, F.U.S.A. did not make use of special "security" editions for briefing purposes. It was arranged, therefore, that the camps would be sealed as soon as the coded bundles were opened. The Engineer (F.U.S.A.) submitted approximately 3,500 detailed map requisitions for units scheduled for the assault, follow-up and build-up. These were received by the Chief Engineer about the middle of May, and the task of breaking them down took one week.

All maps for assault units scheduled for "Omaha" beach were delivered to the marshalling depot at Dorchester, and those for assault units destined for "Utah" beach were placed in a marshalling depot at Totnes. The maps required for follow-up units from "D"-day to "D" + 3 were delivered to a depot at Truro, where Southern Base Section assumed responsibility for further breakdown and delivery.

The requisitions covering units in "pre-loaded build-up tables" were tabulated, and the proper quantities of maps were placed in the nearest marshalling depot, from where they were delivered to the camp map depots. This breakdown took into account the movement of units into camps and areas where they were briefed before being assigned to definite craft.

In general, units scheduled for arrival on the Continent up to "D" + 15 were supplied with all scales of maps for their initial missions, and small scale maps only for missions beyond "D" + 15. Units scheduled for arrival after "D" + 15 were given only maps on 1/250,000 scale and smaller. Larger scale maps were issued to them when their missions had been determined.

Security. Maps were under guard at all times before issue, and all consignments from depots to camps were convoyed by an officer and armed guards, with one guard riding on the actual load to see that nothing fell out on the road. When any coded rolls were opened, all personnel were segregated under strict security control until the lifting of security was authorized. Every issue of maps was made from one officer to another only after proper identification had been established.

Comments. The following were some of the principal factors which complicated the problem of map distribution to U.S. units in the marshalling areas:—

- (i) The late receipt of requisitions from F.U.S.A.
- (ii) The necessity for building up an organization for the preparation and breakdown of stocks and the actual distribution, a task for which there had been no precedent on such a vast scale, and for which few of the personnel employed had any previous experience.
- (iii) A natural confusion caused by the movement of large numbers of men and vehicles in a restricted area.
- (iv) The stringent security measures which had to be maintained.

During the assault phase, the initial map issues for F.U.S.A. involved approximately 1,350,000 maps. Generally speaking, the distribution pro-

cedure worked well despite the many problems that were encountered. It was reported that units arriving overseas between D"-day and "D" + 3 were well mapped, but in the case of some units arriving after that date, and who had been in the marshalling areas for too short a period to secure their maps, they reached France inadequately supplied.

Considering all the possibilities for leakage, the preservation of "security" left nothing to be desired.

Initial build-up of British map stocks overseas

With corps and divisions. The attachment of sub-sections of 3 (Army) Field Survey Depot R.E. with racked map lorries to the headquarters of corps and divisions enabled the assault formations to take with them a limited supply of maps in addition to those which had been issued to them in the marshalling areas. These lorried maps comprised a small reserve stock of the immediate assault area, and a full issue covering their probable operational area immediately ahead.

With H.Q. Second Army. The major portion of 3 (Army) Field Survey Depot R.E. crossed over to Normandy on light scales in eight detachments (excluding the 16 corps and divisional sub-sections) as under:—

- | | | |
|------|--|----------------------|
| 1st. | 2 O.R.s (on "D"-day) with 5 tons of maps | } On separate craft. |
| 2nd. | 2 O.R.s (on "D"-day) with 5 tons of maps | |
| 3rd. | Main Depot—2 officers, 10 O.R.s, 1 jeep, 3 3-ton lorries. | |
| 4th. | 2 O.R.s attached to the Survey Directorate, for Army H.Q. map lorry. | |
| 5th. | 2 O.R.s with 20 tons of maps. | |
| 6th. | 2 O.R.s with 20 tons of maps. | |
| 7th. | 2 O.R.s with 20 tons of maps. | |
| 8th. | Rear Depot—1 officer, 17 O.R.s, 3 3-ton lorries, 2 15-cwt. trucks. | |

The first and second detachments went over attached to H.Q.s 1 and 30 Corps respectively, each with maps of the other corps' front, in case divisions should be switched during the initial operations. This did, in fact, happen, and these two detachments issued quite a lot of maps.

The fifth, sixth and seventh detachments went over with their maps pre-loaded on vehicles of other units (R.A.S.C., etc.). The two men were merely conductors, to ensure that the maps safely reached the Army Field Survey Depot. These precautions were fully justified in the event, for the maps of No. 3 Depot arrived promptly, but other map consignments, which went over consigned as stores, often hung around for days in ordnance depots until found and rescued by Survey search parties.

The residues followed later, consisting of:—

Main Depot—5 O.R.s, 3 3-ton lorries, 1 15-cwt. truck.

Rear Depot—5 O.R.s.

All the Second Army map consignments crossed over safely except for one lorry-load which was "drowned" on landing, though most of the maps were salvaged.

With H.Q. 21 Army Group. Pending the move overseas of H.Q. 21 Army Group, 4 Field Survey Depot R.E. crossed over to France during June and was temporarily under command of D.D. Survey Second Army. 5 Field Survey

(Stores) Depot R.E. followed soon after, both units being accommodated firstly under canvas, and then in buildings.

Consignments of maps and stores were shipped to France by normal convoys, and losses were negligible. Both depots became well stocked and, with the arrival of Survey Directorate 21 Army Group within the bridgehead, the depots reverted to 21 Army Group command. After the capture of Caen, a good factory building on the outskirts was allocated to No. 4 Depot, and stocks of maps from the United Kingdom could be shipped up the canal direct to Caen. This base map depot soon began to accumulate large stocks, both from the United Kingdom direct, and also from 21 Army Group survey units engaged on local map printing.

Build-up of American map stocks in the bridgehead

SUPPLY FROM THE UNITED KINGDOM

The American organization for the shipment of bulk map stocks over to Normandy was different from that used by the British. As stated the latter arranged for early bulk stocks to go over pre-loaded in vehicles, accompanied by survey personnel as couriers, to ensure their early removal from the beach areas to the map depot. The Americans, however, arranged for unaccompanied bulk shipment, the maps being packed in wood cases which, when they eventually reached the beach, tended to lie about until found, claimed, and sorted out for removal.

Two map depot detachments were assigned to the assault forces under the control of First U.S. Army, and they operated beach map depots, one each in the "Omaha" and "Utah" beach maintenance areas. During the early phases of the operation, map supply was extremely critical because of the difficulty first of all in locating the map ships, and then getting them unloaded. The original detachments had to be supplemented with extra personnel and vehicles so as to speed up the collection of the map-cases as they arrived on the beaches, and their transportation to the map depot. Information of ship names and numbers was difficult to obtain, and it was often impossible to locate a particular ship lying off the beach area because of the confusion during the first week of the operation, and rival claims for priority of unloading.

To meet early demands, large quantities of maps had to be flown over to make good the delays due to difficulties of unloading. Officer couriers accompanied these air-shipments, and later went also with the sea-shipments, as it was realized that this was the only way of ensuring prompt unloading and delivery of the maps to the depots. Between "D"-day and "D" + 56 over 150 tons of maps were sent across by air, and over 1,000 tons by sea for use by U.S. troops in France.

In mid-July, the forward echelon of the Communications Zone, augmented by extra personnel to control distribution within the American sector of the bridgehead, took over responsibility for the operation of beach map depots, and the establishment of new ones.

Detailed plans for the shipment of map reserves to support the American invasion forces were now implemented. To start with, an average daily shipment of 15 tons was sent over, increasing later to 30 tons. Phased shipments were designed to provide a moderate reserve of maps in the immediate beach-head area, and an initial issue to meet a 14-day requirement for mobile operations under break-through conditions.

To guard against total loss of any one map sheet, not more than 10,000 copies of any particular sheet were loaded on one ship. The wisdom of this precaution was proved when the sinking of a few ship-loads at a critical period did not cause a breakdown in map supply.

The systematic shipments described above, which were designed to carry through to about "D" + 90, had to be modified in August so as to send over bulk stocks amounting to about 1,500 tons to the U.S. Base Map Depot at Rennes. This was owing to a change of tactical plan involving the rapid exploitation of a break-through, and the erratic delivery of maps on scheduled periodic shipments. Delivery by normal sea convoy could not be guaranteed within any reasonable period of time so air-shipments and "Red Ball" (special priority) transportation were made use of to meet urgent requirements occasioned either by failure in the delivery of map reserves, or unexpectedly high consumption of particular sheets.

SUPPLY FROM THE UNITED STATES

In December, 1943, as stated previously, it was agreed between the War Office and the War Department, Washington, that the former would be responsible for bulk map supply to American forces taking part in "Overlord" during the initial stages of the operation, and that the Army Map Service (A.M.S.) in Washington would assume responsibility for supply to the Continent after "D" + 90. After discussion between D. Survey (S.H.A.E.F.) and Colonel Milwit (E.T.O.U.S.A.) requisitions for map stocks to be printed in the United States were sent to Washington starting in April, 1944. These requisitions called for monthly consignments to be despatched beginning on 15th July which, allowing about four weeks for the journey, would bring the first shipment into European waters about the middle of August (approximately "D" + 70). Probable output was based on a production figure of about 7,500,000 maps each month.

In accordance with the above arrangement, there were about 30,000,000 maps in ships around the coast of Britain and in the English Channel towards the end of August. They were loaded in stores ships, supposedly for priority discharge. At that date the allied armies had broken out from the Normandy bridgehead and were racing eastwards. First U.S. Army was moving through north-eastern France into Belgium, and General Patton's Third Army was racing along south of Paris towards the German frontier. The map supply situation with the above armies was, at that moment, extremely critical, and it was vital that the large stocks of those very maps of eastern France, Belgium and western Germany which were so urgently needed by the advancing armies, and which were afloat off the English coast, should be unloaded immediately. The locations of the ships were established but, though the cases of maps were listed on the manifests as cargo for priority unloading, they had been put in the holds below low-priority cargo, such as locomotives, which required special port facilities for removal. This unfortunate mistake at the port of embarkation completely nullified the advance map-supply planning which should have made the maps available well in advance of anticipated needs. It required most urgent representation to the highest level before an order was given for the ships to be unloaded immediately, and the map stocks were then sent forward.

At the same time action was taken with Washington to speed up the delivery of succeeding consignments which were then loading in New York.

The maps concerned covered areas only a short way ahead of the advancing armies, so these stocks were sent over in fast craft and their arrival considerably relieved the strain imposed on local reproduction facilities.

Supply and distribution during the Normandy operations

As soon as map provision had been made for the security of the bridgehead, it was necessary to stock up the corps and divisional map lorries with maps of areas which lay ahead.

As a precaution against possible difficulties in the printing of 1/25,000 maps in the field during the early operations, a thin spread of sheets covering the area from Troarn in the west to the R. Seine was sent over from the United Kingdom so as to be available if required.

It is of importance to note that the nature of the fighting in the close "bocage" country of Normandy, with its small fields and numerous banks, walls and hedges, caused an unexpectedly high demand for 1/25,000 maps by all arms. Under such conditions this scale of map was found essential, even for tanks, especially when operating in close support of infantry. Formations complained that the 1/50,000 maps were insufficiently detailed, and their use was costing lives. Second Army undertook to maintain 1/25,000 map issues at a scale of 800 copies to a division, 800 for corps troops, and 200 for tank brigades, which was over double the standard scale of issue. For certain set battles these numbers were largely exceeded. The maintenance of this output depended on a large increase in paper stocks and later, when it became necessary to increase the printing output of survey units, an extra printing section was added to each field survey company.

During the first three weeks of August receipts and issues continued normally, stocks being adequate and demands being promptly met. Bulk supplies were obtained from 4 Field Survey Depot and these were supplemented by the local printing of 1/25,000 maps. As a result 3 (Army) Field Survey Depot with Second Army was kept well stocked, and forward supply to corps and divisions presented no great difficulty.

The pursuit from Normandy through north-eastern France

WITH 21 ARMY GROUP

This fast-moving period of operations was marked by events which stretched the survey organization beyond the point where all map demands could be fully met, and it became necessary for the General Staff to warn the armies that the scale of map supply would have to be restricted. A considerable strain was thrown on all the Survey Directorates concerned. Normal procedure of supply and distribution to a large extent broke down, and it was only by the most intense efforts and skilful improvisation that the lower formations were enabled to receive their essential map stocks.

From the moment when the allied armies broke out of the bridgehead until the advance was subsequently checked roughly along the German frontier, most of the activities of the Survey Directorate at H.Q. 21 Army Group were centred around map distribution. The system of map supply had been organized on the following basis:—

- (a) Maps required for the current operation to be in the hands of the users.
- (b) Maps for the next phase to be in the corps and divisional map lorries.

- (c) Maps for the next succeeding phase to be held in the army field survey depots.
- (d) Maps for further use to be in the Base Map Depot, ready for issue to army map depots some three weeks before they were likely to be required for operational use.

Experience in Second Army indicated that army map depots should receive stocks earlier than as stated above. Corps and divisions required a planning issue a month ahead, including 1/25,000 maps, and they started demanding operational stocks for their map lorries about three weeks ahead. The Army Depot, on this calculation, would need to receive its map stocks some six to eight weeks before they were likely to be required for operational use and this offered a difficult problem in map supply.

The pursuit after the Falaise battle was carried out at such speed that the normal map supply organization was completely upset. The enemy did not stand on any of the potential defence lines, such as the R. Somme, as had been anticipated, in order to maintain his V-weapon sites in the Pas de Calais, and movement thus got ahead of bulk delivery from the United Kingdom. The Map Reproduction Sections R.E. had not yet become fully operative in France, so it was necessary to depend very largely on consignments from England. During the later stages of the advance across the Somme and beyond, the required maps were not available in the depots in sufficient numbers, and the business of map distribution became an exacting process of hand-to-mouth improvisation so as to feed stocks forward piecemeal as they were shipped over. Owing to the heavy demands on "pool" transport for carrying forward petrol, ammunition, and other urgent supplies, vehicles from many of the survey units were diverted from their normal use for map transportation.

The reader may well ask at this stage why it was that such a shortage of maps of north-eastern France and Belgium should have come about. It may be well, therefore, to consider briefly the basis on which the printing and supply of bulk map stocks for this stage of the operations had been planned.

At the Washington Conference in May, 1943, the conception of a full scale invasion of western Europe was confirmed, and the spring of 1944 was designated as the target date. By August, 1943, the joint Anglo-American planning staff (C.O.S.S.A.C.) had produced a tentative plan, and this enabled the Survey Directorate (War Office) to concentrate in detail on the preparation of the various map series, already well advanced, which were likely to be required. As it was desirable to incorporate as much up-to-date revision in these maps as possible, and as the numbers to be printed would depend on detailed planning by the formations concerned, it was obviously desirable to defer the printing of bulk stocks until more precise data were available.

By January, 1944, it became clear that the extent of the mapping commitment was such that no further delay in starting the actual printing could be tolerated. At that date, D. Survey 21 Army Group had still not received sufficient information on which to base a precise forecast of requirements other than the approximate number of divisions that were likely to take part in the assault, and the fact that the target date was some time in the spring. Under the circumstances his printing demand had to be based very largely on intelligent guesswork.

As detailed planning proceeded, and the estimates of the British and American Armies for the assault and the period immediately following began

to come in, it was apparent that the numbers now being asked for greatly exceeded the January estimate. This was due to the fact that, when planning the assault and the subsequent break-out from the beach-head, each army expected map provision to be made for possible extensions to either flank and also to the south.

In April, 1944, the planners prepared a phase-line map which indicated the anticipated development of the operation. This showed that, by "D" + 90, the allied armies were expected to reach the Rivers Seine and Loire, and to have cleared the Brittany peninsula. This phase map assumed great importance with regard to planning for map supply. The area covered up to the "D" + 90 phase-line was a large one, and the demand for small and medium scale map cover of this area represented an enormous printing commitment. This was aggravated by the fact that the mobile printing equipment with American units was, in those early days, not of a suitable size for printing 1/25,000 maps in the field. The U.S. Forces asked, therefore, for large numbers of 1/25,000 maps of the Brittany peninsula and of the area north of the R. Loire to be printed for them to take over. The demand for many of the 1/50,000 and 1/250,000 sheets amounted to well over 100,000 copies of each and, in the case of the 1/25,000 sheets, of which there were a very large number, the number required of each varied from 10,000 to 25,000. There was a further unexpected load on printing resources when Second Army demanded 1/100,000 maps at the full scale of issue. The current policy was that this scale of map was to be issued only to armoured formations, but the General Staff ruled that this new demand should be met.

Consequent on the above, very large supplementary printing orders had to be placed with the War Office, and indices were prepared showing the numbers of each sheet which were to be delivered either to the static map depots, the marshalling area depots, 21 Army Group depots for onward transmission, or to be forwarded as freight after 21 Army Group depots had gone overseas. Dates by which delivery was required were also given.

The available printing resources in the United Kingdom were extensive but not unlimited. They were quite unable to meet the demands that had now been submitted to the War Office. D. Survey 21 Army Group was therefore informed in April that he must either reduce the quantities asked for of the assault area and just beyond, or accept later delivery dates for the maps of north-eastern France, Belgium, Holland and Germany. On receipt of this communication, the General Staff, 21 Army Group, made the following two decisions. Firstly that the maps asked for by the assault and follow-up troops must be provided in the quantities required, and nothing was to prejudice this. Secondly that Survey should plan for subsequent requirements on an assurance that the advance would not go beyond the "D" + 90 phase-line before that date.

While considering the question of map stocks in the assault and break-out area it must be realized that, instead of going more rapidly than forecast, as in fact it did, the operation might have gone more slowly, and in that case many of the apparently redundant stocks of maps west of the R. Seine would have been in considerable demand.

For an estimate of map requirements beyond the "D" + 90 phase-line, no indication was available at the early planning stage of the probable rate of advance beyond that line. It was therefore assumed that, after a short pause on the R. Seine, the advance to the north-east through France and

Belgium would continue at about the same speed as shown by the phase-lines leading up to the Seine, about 50 miles a month. As events turned out the pursuit proceeded at the rate of about 40 miles a day during a period of about six days. The Guards Armoured Division entered Brussels on 3rd September and 11 Armoured Division entered Antwerp on 4th September. Second Army was therefore about 200 miles ahead of schedule by "D" + 90, and had entered an area which, according to the planned estimate, would not have been reached until about "D" + 210.

Returning now to April, 1944, the War Office printing programme was re-examined in the light of the decisions made by 21 Army Group, and it was estimated that requirements could just about be met. The phasing of the post-assault consignments was based on the assumption that stocks must reach 21 Army Group Base Depot in France about four weeks before they were likely to be required for operational use, and it was assumed that the transit time from the War Office Map Depot to the Base Depot would be about 10 to 14 days. On this assumption maps of the R. Somme area should have been arriving in 21 Army Group Depots about "D" + 70, say mid-August. On the phase-line estimate the maps of more forward areas had not been planned to reach France till about mid-September. When that date arrived the maps of those areas were, in some cases, only just coming off the machines, and the only stock available in France was a small quantity which War Office allotted to 21 Army Group from an early printing which had been run off for use by the planning staffs. This allocation was very small as War Office had to hold back a small reserve for possible use by airborne forces.

In the light of events as now known, the quantity of maps of the area west of the Seine might have been considerably reduced, with consequent speed-up of production of maps further to the east, but this would have been a bold and unjustifiably rash decision to make in April or May, 1944. In any case, despite the shortages recorded above, it is satisfactory to chronicle a statement made by Field-Marshal Montgomery to D. Survey 21 Army Group to the effect that at no time did map supply fail or prejudice the conduct of operations.

On several occasions it was necessary to interchange map stocks between British and American Army Groups. Each was in possession of stocks not required by themselves but urgently needed by the other, and 12th U.S. Army Group gave valuable help when supplies were dangerously low in Second British and First Canadian Armies. The advantage was mutual.

A labour difficulty arose in connection with the hand-to-mouth procedure of feeding maps forward from the base map depot. Large consignments arriving from the United Kingdom had to be sorted and re-consigned with the utmost speed. For this the personnel authorized for a standard field survey depot were quite inadequate. During most of August, the labour employed at the depot was of the order of 100 persons including French civilians and typists, British and other pioneers, and all available survey reinforcements. Three officers were always necessary instead of the one allowed by war establishment.

During the latter part of August, Nos. 14 and 15 Map Reproduction Sections R.E., equipped with double-demy printing machines, were installed close to H.Q. 21 Army Group in Normandy and they, together with 515 Field Survey Company R.E. and its mobile demy printing plant, were able to supplement the bulk stocks received from the United Kingdom. No. 25 Field Survey Depot R.E. arrived in France at the end of August. Its task was to function

as a L. of C. depot, handling both maps and survey stores sent forward from the base depots, and feeding them further forward to the British and Canadian Armies.

WITH THE BRITISH AND CANADIAN ARMIES

Anxious though the situation was at Survey Directorate, 21 Army Group, the D.D.s Survey at the headquarters of Second British and First Canadian Armies had a greater anxiety. They were closer to the fighting troops, and were responsible directly for their map supply. During the rapid advance from Falaise in late August it was apparent to D.D. Survey Second Army (Colonel A. W. Heap) that normal methods would not cope with the situation. At one time, for example, one of the corps rapidly advanced 100 miles ahead of Army H.Q. and the field survey depot. When the advance began corps and divisions were carrying in their map lorries map supplies which would take them up to and across the R. Seine. Map coverage up to the R. Somme was carried by 3 (Army) Field Survey Depot, and indents for maps extending from the Somme into Belgium had been sent to H.Q. 21 Army Group. Stocks of these were not available, and a map crisis rapidly developed. Matters were not made any easier by the fact that 3 Field Survey Depot was constantly on the move in order to keep pace with Army H.Q.

Emergency action was taken by allotting to 3 Field Survey Depot the personnel and transport of two topographical sections and two general survey sections to speed up movement, and by obtaining 20 3-ton R.A.S.C. lorries and a platoon of pioneers. At the same time a mobile map dump consisting of three 3-ton lorries and a topographical section from a field survey company was sent forward to H.Q. 30 Corps with a load of 1/50,000 and 1/250,000 maps of forward areas. Formations were instructed to demand direct on this mobile dump. To speed up the forward move of the main depot all redundant maps of rear areas were progressively dumped at locations which were notified to H.Q. 21 Army Group so that they could be salvaged.

This emergency procedure continued till the end of August. Depot accounting had to be dispensed with, and maps were issued to formations before they had been checked in to the depot. This naturally produced a chaotic situation with regard to stock records, and it was essential to return to normal methods as soon as possible.

The Canadian Army experienced much the same difficulties in its advance up the left wing through the Pas de Calais and they found it necessary to augment considerably the transport with their field survey depot so as to effect the quick deliveries that were necessary day by day.

WITH THE AMERICAN ARMIES

For the assault, and the subsequent operations within the bridgehead, First U.S. Army was under the command of 21 Army Group. As soon, however, as the Third U.S. Army became operational and the break-out from the bridgehead began, 12th U.S. Army Group assumed command of the First and Third U.S. Armies, and the topographical detachment of the Engineer Section at Army Group H.Q., under Colonel W. D. Milne, took over general control of their map requirements. A few words on the organization for supplying maps to American field formations are advisable, as it differed from the British method whereby the survey service was responsible for all mapping

and survey matters. In the American Army the responsibility for map supply and surveys rested with the Engineer at the headquarters of each formation. Shortly before "D"-day the engineer sections at army group and army H.Q.s were strengthened by the addition of a Topographical Detachment which was responsible to the Engineer for all mapping and survey matters.

The topographical engineer at an army group H.Q., after consultation with the Operations (G-3) and Intelligence (G-2) staffs, decided what maps were likely to be required for future operations, and notified the Engineer Intelligence Division (Communications Zone). The latter was responsible for ensuring that bulk map stocks, including those for the air forces, were assembled in the base map depot on the Continent. These stocks, as mentioned previously, came first of all from map depots in the United Kingdom, and subsequently direct from the United States. The ordering of these stocks was generally arranged after discussion between D. Survey (S.H.A.E.F.) and Colonel H. Milwit, Chief of the Intelligence Division, between whom there was at all times the closest of liaison.

From the base map depot stocks were transferred to advanced map depots, one of which was located just behind the rear boundary of each army area. These advanced depots were manned by map depot detachments provided by Com. Z. The topographical engineer at each army H.Q. organized his own map depot in which to hold map stocks for operations immediately ahead, and he obtained these from the Com. Z advanced map depot. Map stocks were also transferred from the base map depot to an air force map depot, from which maps were supplied to the various air force commands.

The general organization as finally developed is shown in Diagram 13, but it is necessary now to look back to the period before this organization was fully functioning on the Continent.

Until 1st August all American map depots on the Continent were under First Army control. Segregation of stocks by areas had not been made, and maps were scattered between several small depots which had been established as part of the emergency organization within the bridgehead. When, therefore, H.Q. 12th U.S. Army Group became operational, its Engineer Section was faced with the task of providing maps for both First and Third Armies. Areas of primary interest were assigned to each of the two armies, and a division of stocks was begun.

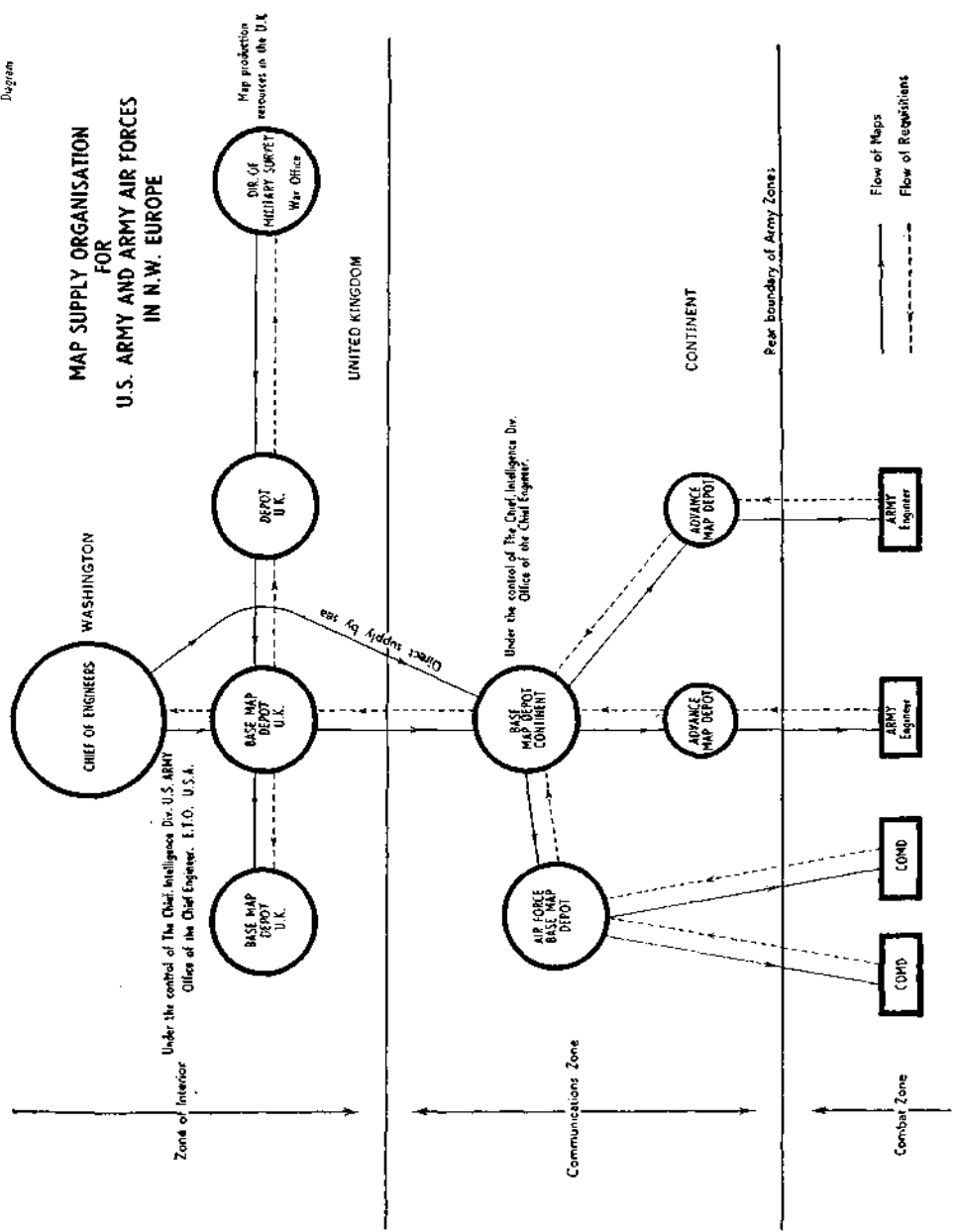
The initial stocks available did not meet the phased requirements of H.Q. 12th Army Group, and it was soon apparent that, unless immediate action was taken to increase stocks overseas, map supply to the armies would fail. Arrangements were made to move all stocks from E.T.O.U.S.A. depots in the United Kingdom to France. This was started on 7th August and was completed by the 24th, by which date the maps had been concentrated at the base map depot at Rennes. Their arrival enabled issues to be made to First and Third Armies at a critical moment of the pursuit battle and, as previously stated, there was close liaison with the Survey Directorate at H.Q. 21 Army Group which facilitated an interchange of map stocks between the two.

On 21st August H.Q. 12th Army Group asked for maps of western Germany, as the armies were racing towards the German frontier. Owing to urgent printing commitments for other needs, the full requirements could not be met from War Office supply but fortunately, with the liberation of Paris, it was possible to arrange with the French Service Géographique for printing to be undertaken there, making use of civilian lithographic resources in the city.

DIAGRAM 13

Diagram

MAP SUPPLY ORGANISATION FOR U.S. ARMY AND ARMY AIR FORCES IN N.W. EUROPE



Stocks of Michelin road maps were also found in Paris, which proved invaluable at a time when the standard military map series were in short supply.

Although, during this difficult period, map supply was undoubtedly restricted and on a hand-to-mouth basis, operations were never at any time held up or endangered by an absence of essential maps. Supply was rendered difficult by five main factors:—

- (a) A failure to segregate map stocks by areas before the active entry of Third Army.
- (b) Delays in meeting the phased map requirements of H.Q. 12th Army Group, partly because of the delays in unloading the shiploads of maps on arrival from the United States.
- (c) The unexpectedly rapid movement of the armies.
- (d) Changes in tactical plans.
- (e) Shortage of transportation for moving map stocks forward.

The pursuit towards the German frontier

WITH 21 ARMY GROUP

The situation during September continued to be source of much anxiety to survey staffs who were responsible for supplying maps to quick-moving formations. The ever-lengthening lines of communication, congested roads, demolished bridges, and difficulties of port clearance all adversely affected the problem. There was always the difficulty of obtaining sufficient vehicles for map transportation in the face of heavy competition for other commodities, and it was often necessary to make use of survey unit transport and personnel to help maintain the forward flow.

The provision of suitable accommodation, especially for map and store depots which required considerable storage space, was always a difficult problem which caused much anxiety and delay. It sometimes appeared as though the operational necessity of having map stocks promptly and efficiently housed in the right place was overlooked by those responsible for allocating accommodation, and that priority was given to other claimants whose activities seemed of far less operational urgency and importance. After the liberation of Brussels, for example, it took several weeks before accommodation was provided for 25 Field Survey Depot with its stocks of maps and stores, and later on, when 4 Field Survey Depot moved into Germany, several months elapsed before it was properly housed.

When No. 16 Map Reproduction Section R.E. arrived in Brussels, it was quickly in production, using plant which was made available by the Belgian Military Cartographic Institute, who gave much valuable help. No. 15 Map Reproduction Section also moved to Brussels, and these units considerably eased the supply situation, especially as stocks of printing paper were found in Brussels.

With Second Army, the map supply crisis was at its height in the early part of September. The corps were advancing so rapidly that they required new maps daily. Army H.Q. was moving forward about twice a week in an attempt to catch up, and became completely out of touch with H.Q. 21 Army Group. Telephone communication was non-existent, and "Immediate" signal messages took anything up to four days to get through. This resulted in an unfortunate

lack of touch between the two survey directorates, except for personal visits over long distances, at a time when close touch for map supply was most desirable.

3 (Army) Field Survey Depot was continuously on the move till 22nd September, when it had the good fortune to spend one whole week in the same place. It was getting further and further away from the Army Group map depots, and yet had to maintain forward issues all the time without a pause. At the height of this critical period, urgently needed map supplies on order from 21 Army Group depots either failed to arrive or did not arrive in time. This was owing partly to the slowness and congestion of communications and transport difficulties, and partly to a shortage of the required maps covering north-eastern Belgium, Holland and Germany, in No. 4 Depot which was still back at Caen.

Rapid movement reduced the need for 1/25,000 maps, so no further stocks of these were printed north of the Somme during the pursuit period. The resources of the mobile printing equipment with Second Army were therefore switched over to the printing of 1/50,000 sheets of Belgium to make good the deficiency. In addition a special Second Army edition, in demy size, of 1/250,000 and 1/100,000 sheets of immediately important areas of western Germany, was published in monochrome, as an insurance against a possible failure to obtain stocks of the standard series if Germany was entered in the near future. Orders were also placed with the Belgian Cartographic Institute for the local printing of standard 1/250,000 and 1/100,000 maps of northern Belgium and Holland to meet the immediate demands of the fighting troops.

The emergency distribution methods adopted during the early days of the advance, although they allowed formations to get their essential maps quickly, resulted in uneven allocations, and the more pushing formations tended to get more than their fair share of rapidly dwindling stocks. It was decided, therefore, to exercise a more rigid control, so as to eke out the available stocks to the best advantage. Corps were notified that no more map demands would be accepted for the time being, but that stocks of essential sheets would be delivered to corps H.Q.s who would sub-allot them to divisions.

On 7th September, in the course of a telephone conversation between D.D. Survey 21 Army Group and Survey Directorate, War Office, the latter suggested sending maps to Normandy by air as they came off the printing presses, to save the time spent in shipping them. As the maps were urgently needed right forward in Belgium by both the Second and Canadian Armies, and as the cross-Channel air trip to Normandy, plus the time necessary to get them forward, would involve so much delay, it was decided to fly the maps from the United Kingdom direct to airfields in the two army areas. On 10th September, the first daily air consignment of two tons arrived. This was increased to four tons daily on 13th September and continued until 2nd October. By 21st September the supply position had eased sufficiently to enable the normal system of distribution to be reinstated, but with restricted issues.

There is no doubt whatever that the introduction of direct air delivery to armies, cutting out the base map depot and the long overland journey through France and Belgium, saved the situation at a very critical moment, and showed the need for flexibility of methods during a crisis.

Air supply from the United Kingdom to army group depots in Brussels continued until about the end of December, 1944, by which time the United Kingdom printing programme had got ahead of immediate needs. Direct supply by sea *via* Ostend, and later Antwerp, was then able to meet requirements,

though frequent use was made of Naval Despatch and "fast freight" services. Consignments of maps were escorted all the way to prevent their getting sidetracked or lost.

WITH 12TH U.S. ARMY GROUP

The critical map supply situation with the American Armies during the early part of the pursuit has already been referred to. The situation was eased by the receipt of about 200 tons of maps which were flown from the United Kingdom, the unloading of the ships containing bulk stocks from the United States, and the immediate utilization of printing resources in Paris as soon as it had been occupied. Colonel Milwit lost no time in augmenting these resources. He took over a factory building on the outskirts of Paris which had been working as a high-class commercial printing plant and was already equipped with lithographic printing presses. Here he installed his G.H.Q. Engineer Topographical Battalion, which was a finely equipped unit capable of high output, and it remained in this location for the remainder of active operations.

By the end of September, the supplies were again under control and working well. Large stocks of enemy maps, including those prepared for the invasion of Britain which were found in Paris, were used for printing on the back to help out the paper supply.

On 15th September H.Q. 6th U.S. Army Group assumed command of the Seventh U.S. and the First French Armies which had landed in southern France and fought their way northwards to make contact with General Eisenhower's forces in the Belfort area. A.F.H.Q. continued to send air shipments of maps from the Mediterranean to supply these two armies, and also despatched a fast sea shipment of about 200 tons via Marseilles. By the end of September the stocks available with 6th Army Group were sufficient to meet their minimum needs on the battle-front with small reserves in the rear. Topographical units were printing most of the 1/50,000 and all the 1/25,000 maps which they required. On arrival in the Belfort area, 6th Army Group came under S.H.A.E.F. command, and Com. Z. then assumed responsibility for their map supply.

The winter pause (October, 1944, to the end of February, 1945)

GENERAL

In comparison with the rapid pursuit from Normandy, the fighting during October and succeeding winter months was of relatively static nature. Increased German resistance and bad weather conditions slowed up operations, and afforded a welcome opportunity for survey staffs to overhaul their map supply arrangements and build up stocks. The increased length of communications made it necessary to deploy map depots well forward and, in the case of 21 Army Group, to take advantage of the opportunity for using ports further to the east for the disembarkation of map stocks, such as Ostend and finally Antwerp, thus cutting out the long road-haul from Caen. The use of air freight for urgently required stocks was continued with great advantage, every consignment being accompanied by a conducting officer.

The need for these conducting officers cannot be too highly stressed. Maps were not carried by air in bulk unless they were very urgently needed. Time and again it happened that, but for the forceful efforts of the conducting officers, air consignments would have been lost or delayed. Cases often occurred of

aircraft being diverted, for operational reasons, from the airfield to which they were originally routed. In such cases the maps were usually dumped on the edge of the airfield where, if unaccompanied, they would have remained. Without the personal efforts of the conducting officer in collecting transport, and finding his way, possibly 50 miles or more, to the army or army group depot, the maps would not have been traced for days or even weeks.

WITH THE BRITISH FORCES

H.Q. 21 Army Group

Amongst the many other increases in war establishment which were approved for the survey organization at this period was the provision of an extra captain with the Survey Directorate. He acted as liaison officer with H.Q. L. of C. to ensure a proper map distribution to L. of C. units who were located over a wide area between Normandy and the Dutch frontier.

The war establishment of No. 4 Field Survey (Base) Depot was largely increased during November, providing two extra officers, upgrading the rank of the O.C. to captain, and adding several extra storemen, drivers, and vehicles, including five 10-ton lorries. This put the unit in better shape to carry out its functions efficiently, and enabled it to shift map stocks more easily when it had to move. The depot was installed and was functioning in Antwerp by January, 1945.

By the end of November, map stocks in hand with the two 21 Army Group depots were as under:—

With 25 Field Survey Depot (L. of C.)	19,525,000
With 4 Field Survey Depot (Base)	14,726,000
	<hr/>
Total	34,251,000
	<hr/>

By the end of February, just before the final allied offensive, this total had risen to over 50,000,000 maps. Stocks now appeared to be adequate for any likely operations for some time to come and, with all the map reproduction sections in full production at Antwerp and Brussels, assisted by Belgian civil labour, local production was now greatly assisting and augmenting bulk supply from the United Kingdom. The survey units operating in Antwerp had to work under most trying conditions during the height of the enemy rocket attacks.

As a precaution against complete loss of stocks by enemy action (V-weapons) the contents of the depots were split and located at different places.

In preparation for a further advance into Germany an advanced map depot was organized in January from Nos. 4 and 25 Depots. Its function was to move forward with essential stocks at short notice, and to deal with demands from field formations until 25 Field Survey Depot had moved forward complete and was ready to resume issues again.

When the enemy counter-attacked in the Ardennes in December the First U.S. Army map depot at Stavelot was overrun. To make good this loss without delay, pending replacement from Com. Z. sources, some 750,000 maps were transferred from 21 Army Group stocks to form a nucleus for a new map depot which was opened by First Army. This interchange of map stocks between British and U.S. Army Groups was frequently arranged, and indicated the sound co-operative spirit which animated the allied survey staffs at all levels.

With Second Army

Map distribution from October to the end of February was, in general, on a normal basis. Owing to the lack of a 1/50,000 map in Holland, increased quantities of 1/25,000 sheets were printed and issued. Formations stated that the 1/100,000 map was not a large enough scale for tactical use in a country of dense and complicated water obstacles, which formed an important tactical feature in that area.

When the enemy counter-attacked in the Ardennes, there was a rush of map demands consequent on the move of Second Army formations to take over part of the First U.S. Army sector, and it was necessary to attach a topographical section to 3 (Army) Field Survey Depot to assist in the handling of these rush issues.

During January, information was received on the probable future boundaries between Second Army and neighbouring formations. This enabled the stock position to be examined and it was found possible to return to 21 Army Group depots a considerable quantity of redundant maps. This still left over 4,000,000 maps in stock and, in the interests of mobility, the holdings with 3 Field Survey Depot were reduced still further during February.

It is of interest to note some figures covering map issues and turnover at the depot. From June, 1944, to January, 1945, average issues amounted to 31,500 a day, with a peak figure of over 105,000 a day during August. The figures for turnover worked out at an average of 147,000 a day over the period, with a peak of 351,600 a day in August during the advance from Normandy.

With First Canadian Army

Approximately 4,000,000 maps were held in stock by 1 Canadian Army Field Survey Depot, and the position being regarded as satisfactory, the normal system of map distribution was employed. As in the case of 21 Army Group, stocks were split so as to reduce the chance of total loss by enemy action. The depot was of the "Army" type, very similar to that with Second Army, with sub-section map lorries at the headquarters of corps and divisions. Two extra sub-sections were added in December, making a total of two corps and seven divisional sub-sections.

WITH THE U.S. FORCES

With more stable conditions along the fighting front from October onwards, there was an opportunity to consolidate the map position. The docking and unloading of ships carrying stocks from the United States, together with further shipments from the United Kingdom and expanding Continental production, helped to brighten the general map supply picture.

To reduce the road-carry to the advanced map depots serving the armies, a new base map depot was opened just north of Liège early in December. In Paris, a French-operated map store was opened holding maps on all scales for supplying French formations.

The German break-through in December tested the effectiveness of the Com. Z. map supply and distribution system. The rapid German advance overran the First Army map depot at Stavelot, the stocks of which were temporarily lost. The advanced map depot under Com. Z. control, which was located just behind the rear army boundary, was left intact and the losses at Stavelot, which had temporarily been made good by transfers from 21 Army

Group stock, were rapidly replaced by Com. Z. who organized an urgent printing programme in Paris. With the threat of further German thrusts westwards, the advanced map depots for First and Ninth U.S. Armies were moved to safer areas to prevent the possibility of capture.

By the end of January the following map depots were in operation under Com. Z. control:—

Base Map Depot No. 1	Cheltenham, England.
Base Map Depot No. 7	Rennes, France.
Base Map Depot No. 8	Paris.
Base Map Depot No. 13	Paris.
Base Map Depot No. 17	Bacour, Belgium.
Advanced Map Depot No. 12	Verdun (Third U.S. Army).
Advanced Map Depot No. 22	Darnieulles (Seventh U.S. Army).
Advanced Map Depot No. 23	Chalons (Fifteenth U.S. Army).
Advanced Map Depot No. 20	Tongres (Ninth U.S. Army).
Advanced Map Depot No. 21	Tirlement (First U.S. Army).

The stock held in the above totalled about 55,000,000 sheets on all scales.

During January, the German offensive had been defeated, the bulge in the battle-front had been eliminated, and map supply conditions returned to normal. Over 30 vehicles of a truck company, which had been diverted from map transport duties when the enemy attacked, were restored to their proper use, and losses in maps were more than made up when the First Army Map Depot, which had been overrun, was again made available, with its stocks practically intact.

The disposal of surplus and salvaged maps was a big problem, owing to a shortage of personnel for sorting, and the lack of vehicles for removing them. Large quantities were being handed in to the advanced depots and, with no pulping facilities in the forward areas, it was necessary to send them to Paris by rail.

A new system governing map issues from the advanced map depots to armies was introduced in January. The Engineer 12th Army Group authorized certain stock credits for each of the armies, and they were entitled to draw only up to the amount of such credit. These credits were frequently revised as found necessary, and the system provided a definite check against extravagant demands.

The receipt from the A.M.S. in the United States of stocks asked for by monthly requisitions, and of "cushion" stocks, continued satisfactory, though there were occasional delays due to shipping and unloading difficulties.

The tactical situation on the fronts of both 6th and 12th Army Groups did not involve any extensive movement during February. In view of the large stocks which had by now been accumulated in the advanced depots, there was a reduced volume of map issues from the base map depots. All the advanced depots were, by the end of February, in an excellent condition for dealing with future operations. To render them more mobile in anticipation of a forward move excess stocks were transferred back to the base.

At the request of D. Survey (S.H.A.E.F.) an advanced map depot was opened by Com. Z. at Maison Laffitte near Paris in support of the First Allied Airborne Army, whose operations from now on were to be based on the Continent.

The final stage (March to May, 1945)

GENERAL

The allied offensive was resumed early in March and, by the end of the month, the British and American Armies had crossed the Rhine on a broad front and were driving deep into Germany. During April, the operations took the form of a series of rapid armoured thrusts involving advances of from 20 to 30 miles a day, closely followed by mobile infantry columns. Canadian forces advanced through Holland on the eastern side of the Zuyder Zee, British forces captured Bremen and were investing Hamburg, and U.S. Armies in the centre had practically encircled the Ruhr and had linked up with the advancing Russian forces on the R. Elbe. Further south the 6th U.S. Army Group had entered Austria and had crossed the frontier into Czechoslovakia.

In spite of all this rapid movement, survey staffs were able to provide the advancing armies with all the maps they required until, with increasing pressure from all quarters, the German Armies finally surrendered on 7th May.

WITH SECOND ARMY DURING THE RHINE BATTLE

The system of map distribution remained normal till the latter end of March, when special arrangements were made for the Rhine battle as described below.

Corps were instructed to stock up their units and map lorries with as deep a coverage of maps astride the planned axis of advance as they could reasonably carry. It was found that, apparently for security reasons, corps and divisions had been given little information about future movements beyond their immediate bridgehead objectives, so they had difficulty in formulating an intelligent map plan. This no doubt accounted for many of the apparently absurd map demands which were received from formations who were doubtless trying to insure against all possibilities.

D.D. Survey, Second Army, notified headquarters of corps that map deliveries across the Rhine would at first be difficult and slow, and that formations must be mapped up beforehand in case of a quick break-through. Accompanying this notification were index diagrams giving a suggested map plan for all formations, and the survey liaison officers with each corps helped formations with useful propaganda and advice. This action met with an enthusiastic response and all the troops concerned were mapped up before "D"-day with maps of all scales as far as Osnabrück.

Three general survey sections, after a few days' training in map issue work, were organized as mobile map sub-depots. Their task was to deal with rapid advances after crossing the Rhine, one sub-depot being attached to each corps H.Q.

Each sub-depot had three 3-ton lorries filled with maps, and four 15-cwt. trucks for transporting maps and moving the personnel and stores. Details of the maps to be held in these mobile sub-depots were prepared in advance by the survey directorate. Briefly the stock consisted of small quantities covering the approaches to Osnabrück, and adequate though not lavish quantities for an initial corps issue on all scales from Osnabrück as far as and including the R. Elbe.

The anticipated break-through occurred earlier than had been expected, and the mobile sub-depots were attached to corps together with the survey liaison officers. The latter supervised the working of the sub-depots, the procedure being as under:—

Divisional demands came to corps H.Q.

The corps "G" staff decided, with advice from the survey liaison officer, whether to supply the maps in whole or in part from the sub-depot, or to send back to the main depot.

The sub-depot was not intended to be used as an overflow for the corps map lorry, and the liaison officer had to watch this carefully and, under "G" control, to direct the maintenance of stocks.

Map stocks were held in the 3-ton lorries only. The 15-cwt. trucks were for the transport of maps to divisions or from the army field survey depot.

The above arrangements worked well, and continued till the close of hostilities. Steps were taken to move forward 3 Field Survey Depot as quickly as possible, so as to keep it reasonably accessible to the sub-depots when they sent back for more maps.

This was the second time, in the case of Second Army, that a break-through occurred necessitating abnormal map distribution arrangements, the essential feature being that *the map stocks had to be mobile*. If this type of quick-moving battle is likely to be normal in future campaigns, it may be necessary for war establishments to provide for really mobile map depots instead of leaving it to survey staffs to improvise on the spot.

When hostilities ceased, the sub-depots were converted to static map depots near the final locations of their respective corps.

WITH THE U.S. FORCES

The rapid advances of the armies during late March caused a sharp rise in issues from base depots to the advanced map depots. By the end of March, four of the latter had moved into Germany, and were making every effort to keep pace with the advancing armies and so reduce delivery distances to a minimum.

Consignments from the United States continued to arrive in accordance with the monthly requisition programme. A total of 960 tons of maps were landed in Continental ports during March. It was found that many of the rail-wagons carrying these maps from the ports tended to get lost *en route* if not closely checked. Many found their way into engineer supply depots and were mixed up with bridges, timber and other engineer stores, causing much delay.

The task of keeping the quick-moving formations well supplied with operational maps covering ever-widening areas during April was not an easy one. A record total of 800 tons was issued from the base to advanced map depots. The wheel southwards of 6th Army Group towards Austria involved the rapid production and issue of maps of Austria and even of northern Italy. These were printed in Paris from reproduction material received from A.F.H.Q. by air.

The ending of hostilities early in May eased up production, but introduced new problems of supply and distribution to meet the needs of redeployment for occupational duties.

It may be of interest to quote a few figures indicating the scope of map supply to the American forces during "Overlord." The total supply for the campaign amounted in round numbers to 210,400,000 maps. Of this number, base facilities under the control of the Chief Engineer furnished 163,900,000,

the remaining 46,500,000 being produced by units under the control of U.S. Army Groups.

The source of supply for those furnished through the base organization was as under:—

Army Map Service (United States)	79,830,000
Institut Géographique National (French)	28,449,000
Base Topographical Battalion (660 Engineers)	17,560,000
British sources	38,061,000
Total	163,900,000

They were issued or disposed of as follows:—

Issued to U.S. Armies	62,000,000
Issued to the Air Forces, Com. Z., 21 Army Group, etc.	11,678,000
Salvaged or converted to pulp	31,429,000
In stock, June, 1945	58,793,000
Total	163,900,000

The above figures represent, over the period of the campaign from June, 1944, to May, 1945, an average daily supply of 486,000 maps from base sources, and 165,000 produced by topographical units in the field.

SECTION 7. MAP SUPPLY FOR THE ALLIED EXPEDITIONARY AIR FORCE

Historical introduction

The principal roles of the R.A.F. during the European war of 1939–45 may be summarized as under:—

Bomber Command—Strategic strikes against the enemy's vulnerable military and economic centres.

Coastal Command—The protection of shipping and the keeping open of the sea lanes.

Fighter Command—The defence of Great Britain and co-operation with ground forces and other Air Commands.

On occasions, aircraft of the above Commands were used outside their normal role as, for example, when Bomber Command was used tactically to assist the ground forces in offensive operations.

For Bomber Command some special "air maps" and "plotting series" had been provided in anticipation of a European war, and special target maps were rapidly produced after the declaration of hostilities.

For Coastal Command, in addition to the above maps, there were Admiralty Charts available, and these were supplemented later by special marine-contoured series of 1/250,000 scale, which were used in connection with mine-laying. Other special series were also produced to meet arising demands.

Before the war, no special maps had been prepared for the use of Fighter Command. It was intended that aircraft engaged in a defensive role should be controlled by wireless from the ground, and it was presumed that aircraft engaged in co-operation with ground forces would use those maps normally used by the Army. Not until the Battle of Britain had been fought and won was action taken to provide special maps for use by fighter aircraft engaged in operations over the Continent and for other offensive action. By the end of 1942 the publication of an Army/Air series covering most of western and southern Europe on a scale of 1/250,000 had been planned (see Chapter XIV, Section 3). Thereafter, the history of special map provision for the air forces was influenced by developments in the tactical handling of aircraft, the production of special aircraft for particular operational purposes, and the increase of radar aids to navigation.

Maps for use with radar aids to navigation (see Plate 56)

Chief among the radar aids was the development of "Gee" for which, early in 1942, the Directorate of Military Survey was producing a series of "Lattice" charts on Mercator's projection covering Great Britain and most of France and Germany on a scale of 1/500,000 (at 56° N. Lat.). They carried hyperbolic curves denoting "Gee" values, each set of curves being based on a particular transmission station. These charts, which had been produced for the use of Bomber and Coastal Commands, were also used by photo-reconnaissance units of Fighter Command, and before long the light bombers of Army Co-operation Command (later the 2nd Tactical Air Force) were equipped with "Gee" boxes, as were also the carriers and tugs of both 2nd T.A.F. and Transport Command.

The problem facing the light bombers, which were employed mainly during daylight, was one of precision bombing at relatively low altitudes. After discussions between users and producers, it was agreed to publish for "Overlord" a series of topographical air maps with overprinted hyperbolic curves relating to wireless transmission signals from mobile "Gee" sets. These latter were established on the Continent as soon as pre-selected sites for them had been cleared by the ground forces. Early in 1944, some sheets based on the 1/500,000 air maps were produced for trial and training, and were successful. Subsequently 13 series totalling about 70 different sheets were produced for operations on the Continent.

They differed from the standard air maps in that the basic detail was printed in a broken black, layer tints were omitted, pastel tints were used for woods, water and roads, and the hyperbolic curves were overprinted in strong colours.

Soon after "D"-day transmission signals from the mobile "Gee" chains were utilized by the heavy bombers of Bomber Command and Eighth U.S.A.A.F. and by the carriers of both Ninth U.S. Troop Carrier Command and Transport Command R.A.F., who found the "Gee Lattice Topo." maps, as the new series was called, of immense value. For the faster and lighter bombers, night fighters and reconnaissance aircraft, whose missions were of long duration, and whose small cockpits made it difficult to change maps during flight, other maps known as "Gee fixing charts," on a scale of 1/1,000,000, were produced.

High-altitude maps for fighter aircraft

For some months before "D"-day, heavy, medium and light aircraft of all air forces located in the United Kingdom were striking at the enemy's com-

munications and centres of production. For these operations standard air maps were used as well as other special maps described above, but, with all this production it was found that provision had not been made for everyone. Single-seater, long-range fighters of the Eighth U.S. Fighter Command were accompanying heavy bombers on daylight raids, travelling very long distances at high altitudes, and for these a series of "High Altitude Fighter" maps at 1/1,000,000 scale was hastily produced.

Lighthouse recognition charts

Many squadrons of Fighter Command and 2nd T.A.F. were striking at the enemy at low level, "hedge-hopping" from their bases to the target. Only the most careful pre-flight study of maps and photographs could bring them to their objectives, and to assist pilots in checking their landfalls and so correct their course, the series of 'Lighthouse Recognition' charts, first designed by Coastal Command, was extended by the addition of sheets covering the English Channel and the North Sea.

Maps for use by close-co-operation squadrons

The assault on the Continent of Europe involved the employment of all air forces and all types of aircraft. Those most directly concerned with the land fighting were the close-co-operation squadrons of 2nd T.A.F., the Tactical Air Forces of the Ninth U.S.A.A.F., and the carriers and tugs of Ninth U.S.A.A.F., 46 Group R.A.F. (Transport Command), and 38 Group R.A.F. (2nd T.A.F.).

Until within a month or two of "D"-day, the squadrons of the Tactical Air Forces co-operating with the ground forces had intended to use the 1/250,000 Army/Air maps, although experience had shown that they were by no means ideal, or indeed adequate, for pin-pointing targets or for communicating with the ground troops whom they were supporting. When the various topographical series at 1/100,000 scale began to be known, more and more pilots felt that they would complete their missions with greater success if they used maps on a larger scale than 1/250,000. A decision was therefore taken that 1/100,000 scale maps should be used and they were published in Army/Air style. There were, in fact, many occasions when even 1/50,000 scale maps were used by pilots during close-support operations over limited areas.

Dropping-zone maps for airborne forces (see Plate 57)

For the carriers and tugs, whose task it was to transport the airborne troops to their dropping zones and landing fields, a special type of dropping-zone map was designed and published. Several trial maps of areas in the United Kingdom were drawn, printed and tested until final agreement was reached on the design and colour. For the airborne operations early in the morning of "D"-day, near the R. Orne in the east and at the base of the Cherbourg Peninsula in the west, special maps on a scale of one inch to one mile were prepared. They were printed in grey and black with magenta roads and town areas, so as to resemble as nearly as possible the appearance of the ground as seen from the air in semi-darkness. As the campaign developed, more of these were produced for the many planned airborne operations, few of which were actually carried out.

Other requirements

Operation "Overlord" involved the preparation of many special maps for the air forces other than those for the use of pilots and navigators. These were required for Air Staff use, for operational control, and for purposes such as briefing and security.

Large numbers of maps dealing with a multitude of subjects were required as appendices to staff memoranda and directives. The Air Staff required also an immense number of display maps for use in conference during planning.

Those required for operational control were few in number but large in area. The four principal "Sector Control" rooms in the south and east of England were equipped with plotting tables on which maps of special design were mounted. The "Headquarter Ships" and "Fighter Direction Tenders" which exercised control in the actual battle-zone during the invasion had to be similarly provided.

Survey organization at H.Q. Allied Expeditionary Air Force

After the evacuation of the B.E.F. from Dunkirk, a system of survey representation with the R.A.F. had been built up. A survey officer was attached to each of the principal R.A.F. Commands in the United Kingdom (*viz.* Fighter, Bomber, and Coastal) to look after their mapping interests, and to form a close liaison between those Commands and the Geographical Section, General Staff (War Office) which was responsible for providing their mapping and survey needs.

When the headquarters of the Allied Expeditionary Air Force was organized, a map section was formed, with Major E. G. Godfrey R.E. as D.A.D. Survey, and an American officer as his deputy. This section was responsible for coordinating the supply of maps to the British and American Air Forces, and the preparation and supply of maps for special purposes. It had its own small drawing office and map store. When first organized, the section was under the control of the Chief Navigation Officer, but was later placed under the Deputy Chief of Operations and Plans to whom Major Godfrey became directly responsible on all matters of policy affecting air force requirements. At the same time he was under the general technical control of the Director of Survey, (S.H.A.E.F.), with whom he maintained at all times the closest liaison.

Responsibility for the actual physical supply of maps to air formations within the A.E.A.F. lay with the following:—

D. Survey (S.H.A.E.F.) (through D.A.D. Survey, A.E.A.F.)—for H.Q. A.E.A.F., and formations operating directly under its control.

The Engineer, 9th U.S. Air Force—for all units of 9th Air Force.

D. Survey 21 Army Group—for 2nd T.A.F., R.A.F.

In October, 1944, H.Q. A.E.A.F. ceased to function as a separate entity and was absorbed into Supreme Headquarters as S.H.A.E.F./Air. The Map Section then became S.H.A.E.F./Air/Maps.

Pre-invasion activities

The period preceding "D"-day was one of intense activity and some anxiety to the Map Section. Late policy changes regarding map distribution to the air forces, delays in making operational requirements known, and belated

demands to meet current needs, taxed the map distribution centres and the drawing office to the utmost.

While the survey depots of 21 Army Group were packing and moving to their marshalling areas, and while the 9th U.S.A.A.F. map store was being re-established, the A.E.A.F. Map Section accepted the additional commitment of supplying maps to 2nd T.A.F. and to certain Commands of 9th U.S.A.A.F.

There were also demands for many special maps to be drawn and printed for the operations branch of H.Q. A.E.A.F., for airborne operations, and for use by controllers in headquarter ships during the assault.

Move of A.E.A.F. Map Section overseas

The Map Section remained in the United Kingdom until late September, when it moved over to France to join H.Q. A.E.A.F. located with S.H.A.E.F. While in the United Kingdom the Section had been fully employed serving the needs of home-based A.E.A.F. formations, including the Carrier Commands. For the many airborne operations that were planned, the Carrier Commands submitted urgent demands for 1/25,000 maps and town and village plans, which required special resources for their immediate production. In August, it was agreed that the Military Survey Directorate (War Office) would assume responsibility for map supply to the Carrier Commands so long as they were based in the United Kingdom. The fact that most of the planned airborne operations were cancelled at the last moment did not affect the need for urgent preparation of the maps as soon as planning for each operation was started.

Although bulk supplies of standard ground and air maps for the allied air forces on the Continent came from War Office and War Department sources, the Map Section undertook the preparation of large numbers of special maps, indices, etc., for use by Air H.Q. and by the allied air forces. Much of the drawing was done in its own drawing office. For reproduction and printing D. Survey (S.H.A.E.F.) arranged that 13 Map Reproduction Section R.E. would assist, and much help was received from 942 U.S. Topographical Aviation Battalion which, with its reproduction train, formed part of the U.S. Army Air Forces on the Continent. There were in addition several reproduction sections of American topographical units assigned to the 9th Air Force.

Transport of maps by air

During critical periods, such as the rapid advance through Belgium and the German offensive in the Ardennes, when normal map distribution arrangements were severely strained, S.H.A.E.F./Air/Maps arranged for map stocks to be flown direct to air formations on the Continent. This followed a procedure similar to that adopted for the ground forces during such periods, and enabled an adequate supply to be maintained at all times.